ELEKTOR ELECTRONICS

THE INTERNATIONAL ELECTRONICS MAGAZINE

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Focus on: Battery Technology

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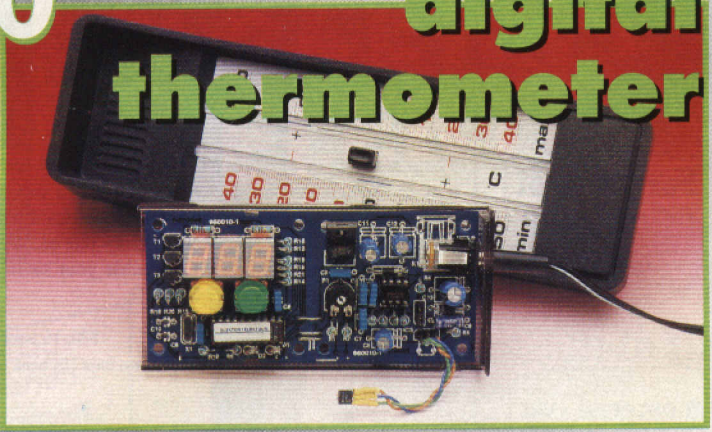

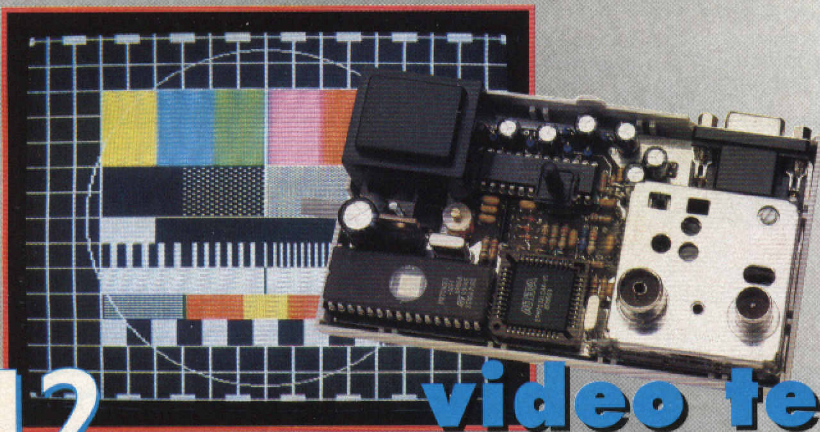

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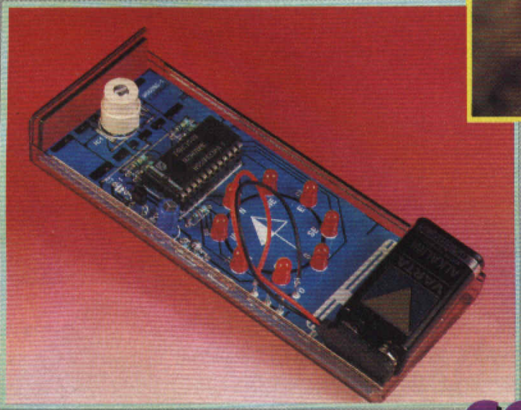

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ABC
AUDIT BUREAU OF CIRCULATIONS
CONSUMER PRESS

END OF THE ROAD FOR THE CD, CD-ROM AND VCR?

Star exhibits at the Consumer Electronics Show held in Las Vegas earlier this year included DVD (digital versatile disc) players shown by some Japanese and a Korean firm. It is almost a year ago that, under pressure from computer companies*, the two sides in the battle for the standard of the high-density disc and the digital video disc reached an agreement, thereby sparing the public having to choose between two incompatible systems. Thus, the Super Density CD from Toshiba/Time Warner, modified to take in certain properties of the Multimedia CD proposed by Sony/Philips, became the digital versatile disc (DVD).

Although there are still some last-minute arguments over the best means of protecting the new disc from piracy, several Japanese, Korean and European companies have stated that they hope to have early production versions of DVD-Video (for films) and DVD-ROM (for video games) players in the shops before Christmas.

There is no doubt that the DVD is the most important piece of consumer electronics since the appearance of the video cassette almost twenty-five years ago. Like the video cassette, the DVD technology will be the king-pin of Japan's electronics industry, with the rest of the world looking on. Pundits reckon that over the next 5–10 years the new technology will almost certainly replace the video cassette, the audio CD and the CD-ROM.

Although the basic development was carried out by Toshiba, Matshushita, the world's largest consumer electronics firm (incorporating National, Panasonic, Technics, and Quasar), Sony and Toshiba will be the main manufacturers of the new equipment. Even Matshushita, however, will not make the laser pick-ups that read the disc. It may be that they will turn to Sanyo, who specialize in making laser pick-ups for reading audio CDs and CD-ROMs. Sanyo have developed a liquid-crystal laser pick-up that can be used for both the DVD and current CDs and which uses fewer parts than any of the current designs.

Pioneer, the market leader in 30 cm laser discs (with a library of some 30,000 titles!) will probably concentrate on manufacturing discs, since 12 cm DVDs are produced on similar machinery as the laser disc.

Outside Japan, one or two Korean firms , such as LG-owned Goldstar, Philips of the Netherlands, and SGS Thomson of France, will, no doubt, take a small slice of the market. Both Philips, an ally of Sony, and SGS Thomson (who own the RCA and GE labels), an ally of Toshiba, have been involved in DVD technology from the start, but they remain heavily dependent on their Japanese allies, who hold the relevant patents (it appears, however, that the patent holders have agreed to license the technology for a royalty of 1.5 per cent per machine).

The DVD and CD have much in common: they are the same size (12 cm dia), which makes them identical in appearance, and use the same basic optical storage technology in which information is represented by microscopic pits – for a detailed description of the process, see *Elektor Electronics*, July/August 1987, p. 39. However, there the similarity ends. The minimum length of the pits on a CD is $0.83\,\mu$m and on a DVD only $0.4\,\mu$m. This results in a density of 6300 tracks cm^{-1} on a CD and 13,400 tracks cm^{-1} on a DVD. Since the recording surface is 33 mm wide, a CD contains about 20,000 tracks, and a DVD, 44,000 tracks. The distance between adjacent tracks on a CD is $1.6\,\mu$m, whereas that on a DVD is $0.74\,\mu$m. A CD contains some 7×10^9 bits, whereas a DVD can store up to 38×10^9 bits per layer (it has two layers, which may be recorded separately). Thus, a DVD can store almost 11 times as much information as a CD, enough to store a full-length feature film in high-quality video with digital sound.

Moreover, the storage capacity of a DVD can be almost doubled to 17 Gigabytes (GB) by the use of four layers, two on each side of the disc.

Owing to the dissimilar dimensions of pits, tracks and track separations, the lasers used in the players are different: CD players use a red (635–650 nm) laser, whereas DVD players use an infrared (780 nm) type.

The DVD player allows a viewer to rewind or fast-forward in a flash.

One drawback, compared with a VCR, is that neither the DVD-Video (for films) nor the DVD-ROM (for video games) can record. However, according to some pundits, recordable versions—the DVD-RAM and DVD-R—will become available before the turn of the century.

Technically, it is already feasible to make a recordable version of the new disc player. Unfortunately (or fortunately if you are in the movie business, since, naturally, most film makers do not cherish the idea of any Tom, Dick and Harry making perfect copies of their films on disc in his living room), the recording of analogue television pictures into the MPEG (Moving Picture Experts Group) code (as used by the new disc) will necessitate complex (and thus expensive) circuitry. This will probably rule a DVD recorder out of court for all but the well-off and commercial recording plants for the next ten years or so.

Unlike the VCR, which has to be compatible with one of the three main television standards: PAL, SECAM and NTSC, the DVD format is universal. Moreover, DVD technology is compatible with current CD technology, so that you will not have to discard your audio CDs and CD-ROMs when you buy a DVD player.

More information on the DVD may be gleaned from http://www.ima.org/forums/imf/dvd/faq.html

[965078-1]

* These companies felt, almost certainly quite correctly, that the likelihood of selling the new disk as a multimedia computer ROM is far greater than using it as a vehicle for Hollywood movies.

LG GROUP IN SOUTH WALES

LG (formerly Lucky Goldstar) Group, a South Korean industrial conglomerate, signed a contract in early July to start the largest microchip plant in Europe at Imperial Park, Newport, South Wales, UK. The total investment is £1.7 bn. The project will create over 6000 jobs on site, and an estimated 15,000 jobs in supplier and support industries.

This is the second large investment attracted by Newport this year: last March, QPL International Holdings of Hong Kong announced a £230 million expansion at its wafer fabrication plant.

[965078-1/2]

MAPLIN IN SOUTH AFRICA

Readers in South Africa may not be aware of the availability in their country of the Maplin catalogue (with prices in Rands) and, of course, all the products therein, from Maplin South Africa (Pty) Ltd, P O Box 1846, Somerset West 7129; telephone 024-515123; fax 024-515127. This offers, of course, an efficient and quick way of obtaining your electronic parts.

[965078-1/3]

First DVD software application

The first software application of the DVD-ROM was announced by Digital Directory Assistance, Inc. One of the new discs contains 112 million US business and residential telephone listings, which previously required six CD-ROMs, and still has one gigabyte of memory to spare.

[965078-1/4]

Optical fibre links Denmark and Sweden

The new optical fibre submarine cable between Elsinore in Denmark and Helsingborg in Sweden will become operational early next month. The cable, called Denmark-Sweden no. 18 (DK-S18) consists of 12 optical fibres and allows transmission of all kinds of telecommunications service.

NEWS

Events

September

3–5. ***World Conference on interactive television*** *at Edinburgh University*

8–11. ***Presentation Technology*** *(professional audio/video products) at Earls Court, London*

8–13. *The* ***CLEO/Europe '96*** *(Conference on lasers and electro-optics) in Hamburg, Germany*

9–11. ***Applications of multimedia systems*** *(vacation school in Lancaster)*

9–11. *The* ***New Telecomms Technologies*** *(residential course in Cambridge)*

9–12. *The* ***European Microwave Conference*** *at Swanley, Kent*

11–13 *The* ***Asia Pacific Digital Cellular Mobile Communications Conference*** *at the Shangri-la Hotel, Singapore*

12–16 *The* ***International Broadcasting Convention,*** *Amsterdam.*

15–18. ***Safety critical systems*** *(vacation school at Cambridge)*

22–25. ***Spread spectrum techniques and applications*** *(International Symposium in Mainz, Germany)*

23–26. ***Intelligent and cognitive systems*** *(International conference in Tehran)*

23–26. ***Dielectric materials, measurements and applications*** *(International conference at University of Bath)*

24–27. ***Antennas and propagation*** *(International symposium in Chiba, Japan)*

25. ***Mobile communications via satellite*** *(Conference of the Royal Aeronautical Society in London)*

25–29. ***Live 96*** *(consumer electronics show) at Earls Court, London*

October

2–4. ***Internet 96*** *at the Business Design Centre, London*

8–10: *The* ***Euro-EMC*** *exhibition at Sandown, UK.*

18–27: *The* ***Connect 96*** *consumer electronics show at the NEC, Birmingham.*

INTERNATIONAL BROADCASTING CONVENTION

A group of over 40 British broadcast equipment and systems companies will launch new products and demonstrate a wide range of system and services at the International Broadcasting Convention, IBC '96, in Amsterdam from 12 to 16 September.

The group, supported by the United Kingdom Department of Trade and Industry, is said by its organizer, the **Federation of the Electronics Industry**, to be the largest-ever from Britain to take part in this prestigious international event, which attracts broadcasters from all over the world.

Detailed information from the Federation of the Electronics Industry, Russell Square House, 10–12 Russell Square, London WC1B 5EE. Phone +44 (0)171 331 2000; fax +44 (0)171 331 2040.

ELECTRONICS RECYCLING FOR LONDON

An estimated 3000 tonnes of electrical and electronic equipment are disposed of in the City of London each year – including more than 2000 tonnes of personal computers and printers, and 500 tonnes of photocopiers.year:

The City's local authority, the Corporation of London, has carried out a survey† measuring the potential for a recycling service to tackle this waste stream.

The Corporation envisages a new recycling plant that provides jobs for Londoners as well as huge environmental and economic benefits. Such a scheme would consist of: • a dedicated collection service; • a sorting facility, close to the City, where initial dismantling and further processing would be carried out as far as practical; • an experienced electronics recycling company contracted to the Corporation, which would operate this facility, market recovered materials and dispose responsibly of residues under Corporation supervision and quality control.; • a procedure for the voluntary sector to select items for refurbishment and further use.

† 'Electronics Recycling in the City of London'. Further details from the Corporation of London on 0171 236 9541.

ARE YOU READY FOR 2000?

It is not generally realized that confusion—to put it mildly—will reign on computers when the new millennium starts. The reason for this is that computer systems store dates as yymmdd (year - month - day), so 20 September 1996 is stored as 960920. When 2000 arrives, any comparison of dates will throw up wrong answers. For instance, a person's age is, typically, calculated by subtracting the year of his/her birth (omitting the first two digits) from the current year. Thus, for instance, a computer will calculate the age of someone born in 1963 by deducting 63 from 96 (= 33). In 2000, this person will be 00–63 = –37! Are you ready to tackle the problems caused by this?

DEGREES FOR INCORPORATED ENGINEERS

Twenty-two degree courses specifically designed for potential Incorporated Engineers are detailed in a new brochure published by the Institution of Electronics and Electrical Incorporated Engineers (IEEIE).

The brochure, *Degrees for Incorporated Engineers*, contains comprehensive information on the courses and details of the universities and colleges offering them. All the courses have been accredited by the IEEIE in association with the Joint Accreditation Board (JAB) for Incorporated Engineers and Engineering Technicians, of which the IEEIE is a founder member, and accepted for IEng registration by the Engineering Council.

WILL A NETWORK COMPUTER SUCCEED?

There is much discussion going on between pundits on whether the promised (threatened?) network computer from Oracle will succeed where, just ten years ago, other 'peoples computers' failed. Oracle feels that the price of the current generation of personal computers is too high and that its operation is too complex.

Although it is generally accepted that most PCs are used for computer games only, the intention of Oracle is to provide the 'average' user with a cheap and simple-to-operate instrument with which he/she can 'send e-mail, surf the Internet, write letters, send a fax , use spreadsheets. The question is: "How many 'average' users want to write letters, send a fax or use a spreadsheet on a computer?". And, if all these facilities are provied, will the network computer still be simple enough to be operated by the 'average' user? These are the questions pundits are asking themselves.

Many insiders believe that with mass unemployment in large parts of the world, Oracle's hope of selling 100 million network computers over the next three years (the first – subcontracted – models are due this month in the USA) seems highly optimistic.

But, assuming it comes true, what will the effect be on the world's telephone networks that will bear the brunt of these new machines? Already, in some areas of the USA, there is at certain times of the day serious overcrowding of the telephone service owing to people using telephone lines for long periods for accessing the Internet.

SUPERCHIPS FROM TEXAS INSTRUMENTS

Texas Instruments has recently announced the development of a chip made in 0.18 μm technology (TI's Timeline Technology) that contains up to 125 million transistors.

The new technology is eminently suitable for the development of ICs for advanced wireless communications, Internet servers and power computer systems.

An IC containing 125 million transistors would be able to contain the logic necessary for constructing 100 current modems. Moreover, such modems would be able to work on a much higher rate than the current 28.8 Kbps. Also, one such IC could contain all the electronics used in current domestic of business systems.

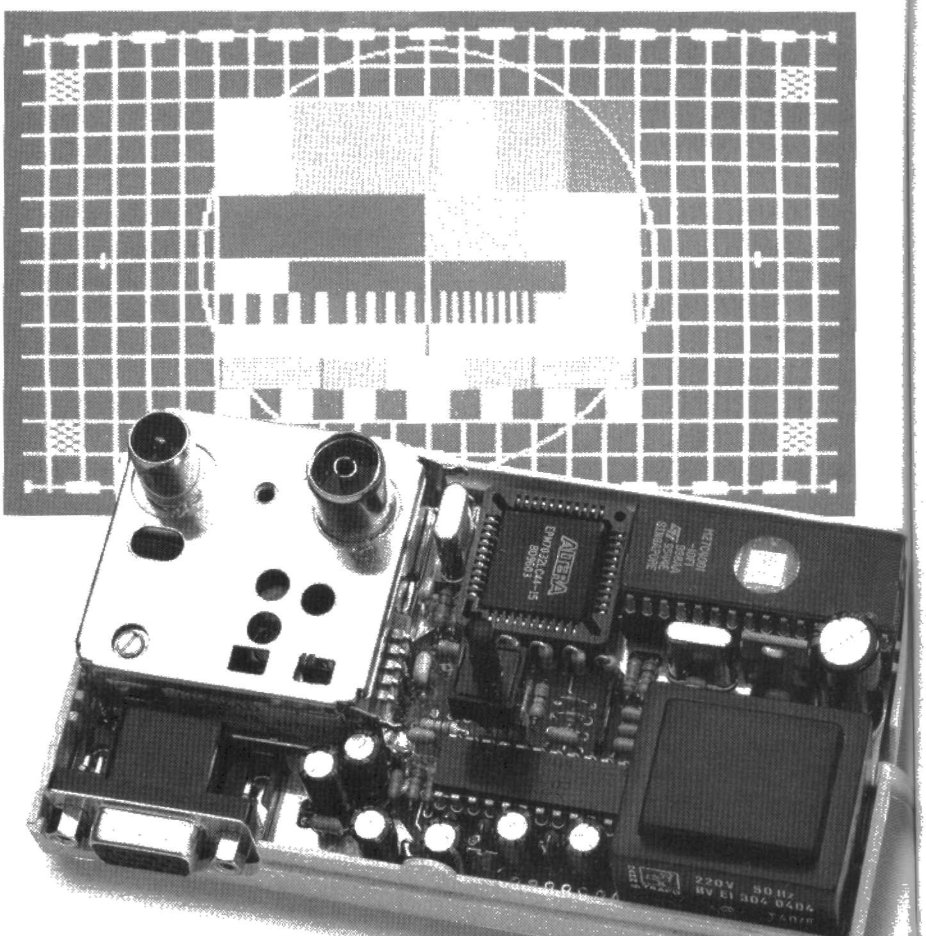
The Timeline Technology will be used in future production of ASICs (Application Specific ICs) and DSPs (Digital Signal Processors).

video test chart generator

part 1

for PAL, PALplus, S-VHS and VGA

The test chart generator described in this article has a number of remarkable features: it is extremely versatile, suitable for testing TV sets (including PALplus types) as well as VGA computer monitors, and sets a 'low' record as regards component count. The total cost of the project being negligible compared with commercially available PALplus generators, this circuit should be of particular interest to TV repair technicians.



Main Specification

- ✓ 12 test charts for PAL, PALplus, S-VHS and VGA, interlaced and non-interlaced
- ✓ Outputs for RGB, H-Sync, V-Sync, Composite Sync, CVBS, component signals Y and C, UHF Ch.30-40 with external AF input
- ✓ All signals digital and frequency locked
- ✓ Quarter-line offset to PAL standard
- ✓ Make your own test charts (requires EPROM programmer)
- ✓ Max. pixel duration 112 ns

Design by W. Foede

To date, PALplus test chart generators are few and far between and expensive, too. The circuit described here is, therefore, a unique opportunity for many TV technicians to generate a PALplus signal in an affordable way. To the electronics engineer with a wider interest than just TV repair, the most important fact is that a single test chart generator is available which can be used for no fewer than four video standards, covering many, if not all, eventualities. Forgetting about the standard voltage regulator on the board, the circuit contains only four integrated circuits: a regular EPROM, a programmed EPLD chip, a type 4040 CMOS counter and a PAL encoder.

The fact that the test charts are stored in EPROM allows you to design your own pictures. The EPROM supplied through our Readers Services contains a total of twelve test charts, six for TV sets and six for VGA monitors.

Complete with its UHF modulator and internal power supply, the generator is a little larger than an old-fashioned pocket calculator. Its power consumption being a mere 4 watts, the generator is definitely suitable for powering from a battery, which may be useful when the instrument is used 'on

1

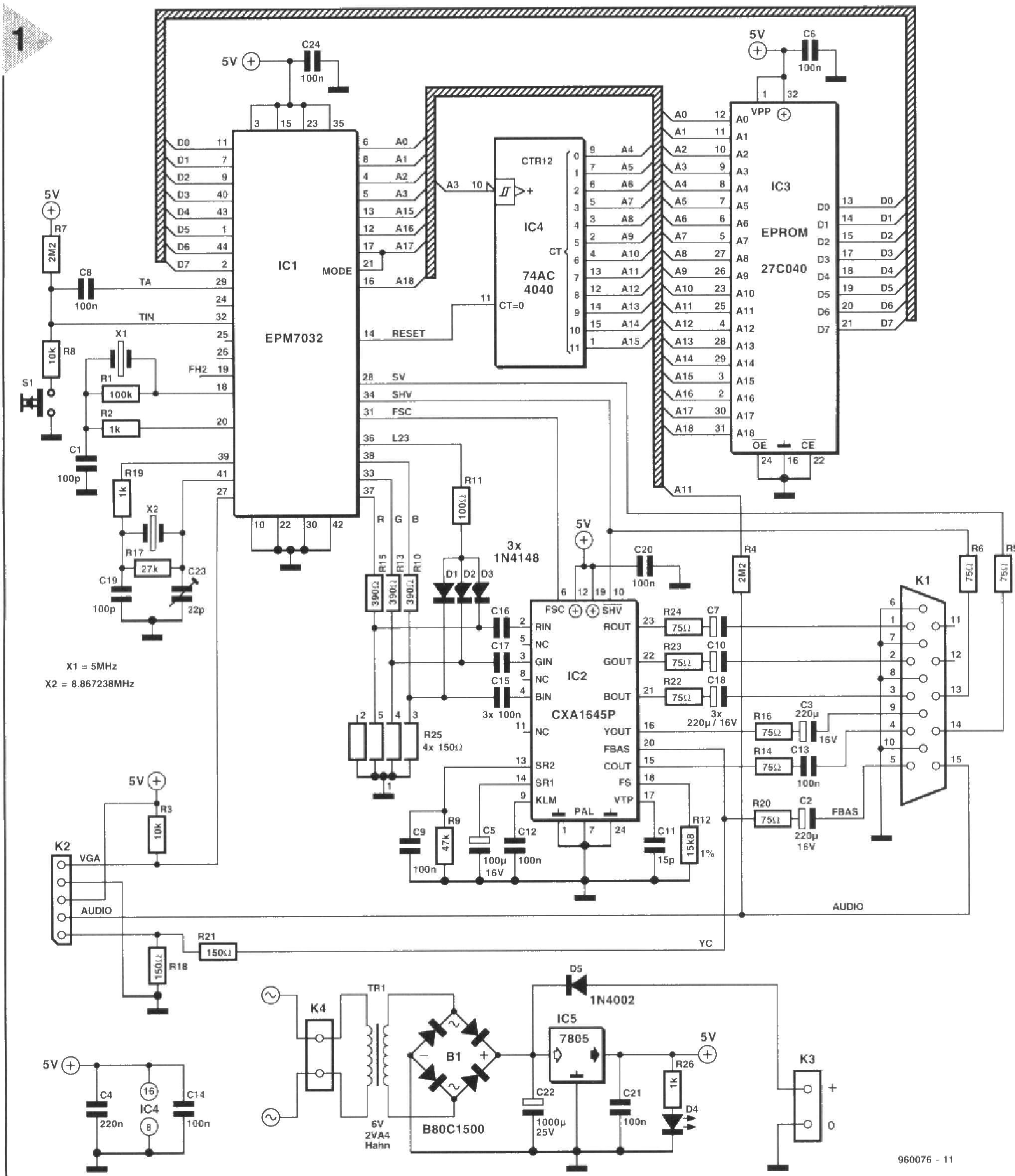


Figure 1. Circuit diagram of the video generator: four tightly interwoven ICs with just a handful of external parts.

the road'. The only controls are a push-button and an on/off switch.

EPLD + EPROM = Video generator

The relatively small number of components seen in the circuit diagram, **Figure 1**, belies the number of functions actually carried out by the circuit. Don't be fooled, however, because the complex generation of the test charts for different standards is carried out by the combination of an EPLD (IC1) and an EPROM (IC3), which *are* intricate circuits. Another high-integration device, IC2, performs the complex function of PAL encoder, while a ready-made UHF modulator is connected to pin row K2.

The EPLD used is the relatively inexpensive type EPM7032 from Altera, which is a good choice for circuits in which standard GALs are uneconomical from a point of view of current consumption and board layout. For the EPM7032, free Windows software is available (ISTEP) which includes a so-called Fitter for automatic routeing and pin assigning. Programmers for this device are affordable, for instance, the LabTool-48 from Advantech. However, you do not need either of these products because the EPM7032 in this project may be obtained ready-programmed through our Readers Services.

The external circuit around IC1 includes two quartz crystal oscillators. The one running at 8.86 MHz is the main clock source from which all

The PALplus format

PALplus is a further development of the PAL (Phase Alternating Line) TV standard, which allows a smooth transition from today's analogue 4:3 to the future 16:9 TV picture format. A feature of PALplus is full downward compatibility without any change to existing equipment. Furthermore, the picture quality is considerably enhanced because cross-effects are avoided, while the visible luminance and chrominance bandwidth are notably improved. In a number of countries, PALplus programmes are already being broadcast.

The basic format processing is sketched in the illustration. With PALplus, the TV camera supplies a picture in actual 16:9 format with 576 active lines. The line times and frequencies are identical with the PAL standard. If such a picture were displayed on a 4:3 TV set, the line duration would be reduced by 25% relative to the picture height: circles then become ellipses. Obviously, the possibility exists to overwrite the sides of the picture, or compress the picture height. Neither solution is entirely satisfactory, while all existing TV sets would have to be upgraded.

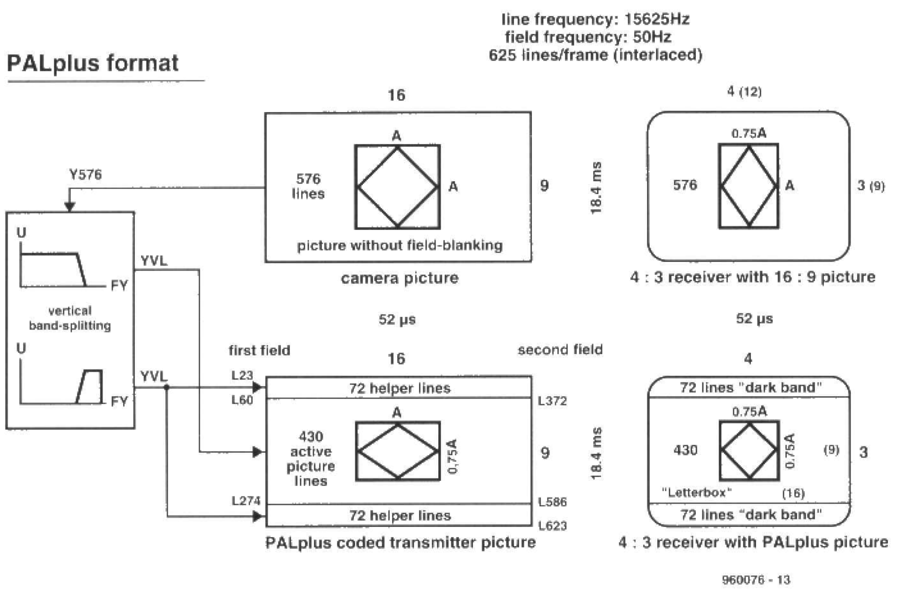
PALplus does not transmit the actual camera image, but a 'core image' reduced to 430 lines with two 'helper' areas of 72 lines each, above and below the core image. These areas are generated by vertical filtering. In simple words, this means that a set of four lines is divided into three core lines and one line from the helper area. Assuming equal contents of both fields, the helper areas are generated from the frame in Film mode, while in Camera mode the source is the field. The contents of the helper lines modulated on a colour subcarrier (CSC) with phase position 0°, like the regular chrominance signal. With a positive signal, that corresponds to blue, and with a negative signal, to yellow. The helper CSC is added at the height of the burst signal, i.e, black, at a level which should not exceed that of the burst. Because of the small signal-to-noise ratio, that process requires the Y signal (brightness) of the helper lines to be reduced in a non-linear manner. The height of the picture so made is 25% too small. On a traditional 4:3 receiver, however, a distortion-free 16:9 picture appears, without lost areas, but with dark helper areas (letterbox) and 430 lines. PALplus transmissions are easily discerned from a regular movie-size 16:9 transmission by looking at the visible picture area. In the dark areas, blue-yellow helper line products occur. A PALplus receiver uses the core and helper lines to restore a proper 16:9 picture with all 576 lines as originally supplied by the camera in the studio.

A comparison between the two formats indicates that the number of lines in a 16:9 picture does not increase, only the line length! If the horizontal resolution is to be upheld, then the number of pixels per line, i.e., the highest Y frequency, must be increased. To reduce cross-colour effects, for example, with non-synchronising colours in finely detailed patterns, and because of the established separation of the brightness and colour information by means of a 4.43-MHz bandpass filter, the highest possible Y frequency with PAL used to be about 3.5 MHz. This has been changed to 'Colour Plus' in the PALplus format. The PAL standard couples the colour subcarrier (CSC) to the line frequency using the fixed ratio 283.7516:1. Two fields of 312.5 lines are transmitted in interlaced fashion. With equal picture contents of the fields, overlapping lines, e.g. lines n and (n+312), have a CSC phase difference of 180°. That allows the Y and C components to be separated in an elegant way. When the lines of both fields are added in phase, the Y signal is automatically obtained, while the C signal remains if the fields are added in anti-phase. This 'clear cut' between Y and C prevents cross-effects between these components, while allowing the full Y bandwidth of about 5 MHz to be used. The same goes for the colour component bandwidth, which increases from 700 kHz to about 1.3 MHz. The procedure is called 'Fixed Colour Plus'. It works provided a field delay is available, and fields have identical contents. Because that only applies to static pictures and film scanning, Colour Plus is extended to 'Motion Adapted Colour Plus' (MACP). The PALplus receiver is controlled by the Wide Screen Signalling (WSS) flag. A search for free lines during the line blanking period only results the first half of line 23 after the start of the first field, and line 623 before the end of the second field. All other invisible lines are already in use for teletext, data and test signals. The WSS signal is a bit pattern in bi-phase level modulation which is derived from a 5-MHz clock. This bit pattern starts with a Run-in code (5 bits), followed by a Start code (4 bits), a Format code (4 bits), an Enhanced Service code (4 bits), a Subtitling code (3 bits) and, finally, a Reserve (spare) code (3 bit).

The run-in and start codes are always equal and serve to synchronise the clock in the PAL plus receiver at 40-ms intervals. The format code arranges the actual picture size control; these 4 bits indicate the picture format to be displayed (wide screen or regular; position of the letterbox). The Enhanced Service code contains information on the Camera/Film mode as well as on the MACP and helper lines modulation. The subtitle bits are set when subtitling is available. The spare bits, finally, may be used for special applications.

The WSS signal has a level of 500 mV$_{pp}$ when the video signal is at 700 mV$_{pp}$. The pattern is easily visible on the screen if you reduce the picture height a little. The remainder of line 23 has an 11-µs long 4.43-MHz burst at the black level. The burst level is 300 mV$_{pp}$ and its phase is 180°, so that the helper lines demodulator is not restricted to the alternating, regular PAL colour burst for reference. Line 623 acts as a reference for the component levels, supplying 10-µs black and white periods. PALplus TV sets are programmed to switch over when the WSS signal has the following bits set (logic 1): Letterbox 16:9 Center, Vertical Helper Encoding and Motion Adaptive Colour Plus. WSS is, incidentally, also reserved for the format transition planned for SECAM.

PALplus format



video frequencies (horizontal, vertical, colour subcarrier) are derived for use in the circuit. It operates in fundamental frequency mode (parallel resonance) and may be fine-tuned with trimmer C23. The 5-MHz oscillator only supplies the bit clock for a digital drive signal which is required for PALplus (WSS signal, see inset box on the PALplus format).

The only other external part is a press-key which is software-debounced by the EPLD, and serves to step through the test charts.

The EPROM is effectively addressed by counters inside the EPLD. The function of these counters is extended by a 12-stage binary counter type 74AC4040 (IC4).

The crux of the circuit is the combination of the EPLD and the EPROM, which stores the test charts in the form of pixels (picture elements), and supplies control signals to the EPLD, enabling this chip to convert the pixel data into a video signal for three different TV formats, or for VGA.

The pixel programming of the test chart enables any pattern you like to be designed and generated 'full-screen'. The largest possible EPROM (27C040) enables six TV and six VGA test charts to be stored, where a TV test chart occupies 512 kBit, and a VGA test chart, 1 Mbit. One byte contains two pixels. Each of the three primary colours, red (R), green (G) and blue (B) requires at least one bit. Giving a total of six colour bits for two pixels, two bits remain in every byte for control signals (see the code table in **Figure 2**). In TV mode, a pixel has a duration of 225 ns, in VGA mode, 112 ns. The switching over of the half-byte (nibble) is controlled by an internal signal (XHL in Fig. 2) of the EPLD. The frequency of this signal is twice as high as the bit clock at A0.

2

HEX EPROM-CODE 1

CODE/4 Bit

$\overline{XHL}$	XHL	(pixelbits)	
10	01	B (D4 D0)	2 pixels/byte
20	02	G (D5 D1)	D3 blocks R/G/B
40	04	R (D6 D2)	

CODE/8 Bit

08	SHV TV/VGA ($\overline{D7}$/D3)
18	SHV blocked in VGA (D4/D3)
28	SHV blocked in TV (D5/D3)
48	SV TV/VGA ($\overline{D7}$/D6/D3)
4A	SV blocked in VGA (D6/D3/D1)
4C	SV blocked in TV (D6/D3/D2)
89	AR TV/VGA (D7/D3/D0)
88	AR TV (D7/D3)
80	XINS WSS (L23) PALplus (R/G/B not blocked)
09	1st Byte SHV blocks FH2 toggle (D0)
19	.. .. ..
29	.. .. ..

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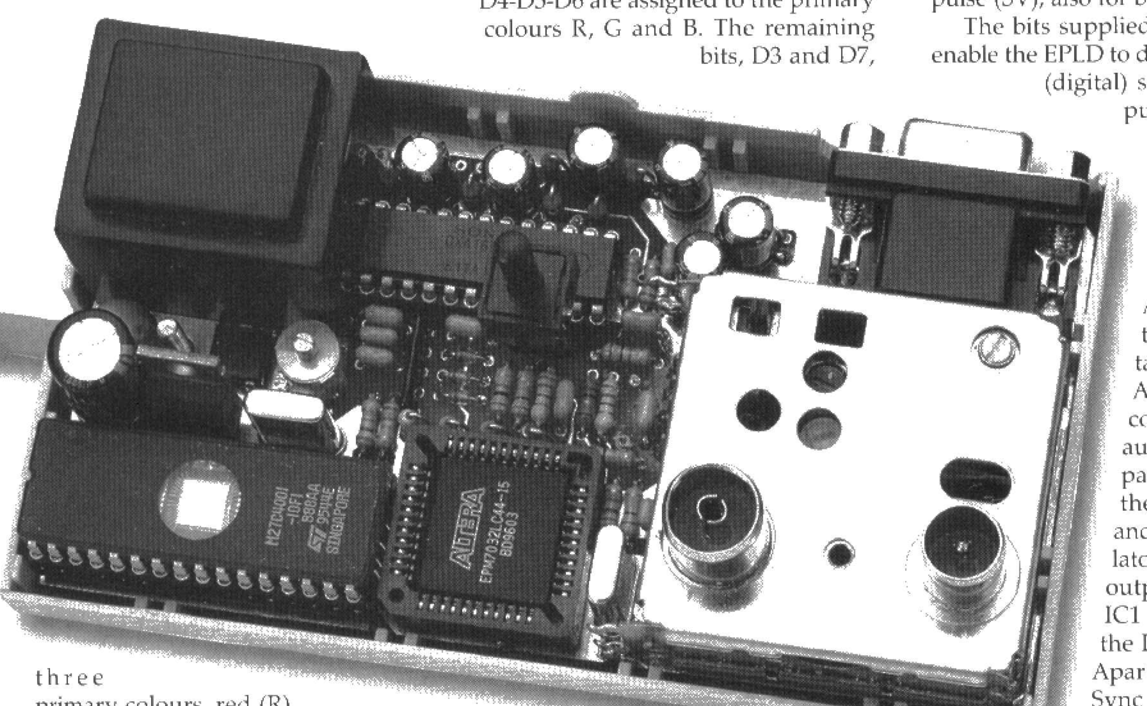
Figure 2. Key to the EPROM-resident test chart codes.

As indicated by the table in Figure 2, the bit triplets D0-D1-D2 and D4-D5-D6 are assigned to the primary colours R, G and B. The remaining bits, D3 and D7, indicate whether the relevant byte represents two pixels or a signal (e.g., a sync pulse). Only when D3 and D7 are at logic 0, the byte is decoded as two pixels. As soon as D3 is set, R, G and B are blocked. The byte, deciphered according to the 8-bit code in Fig. 2, then represents control information. Code 08, for example, causes a sync pulse (SHV) for TV as well as VGA test charts. Similarly, code 48 brings about a raster sync pulse (SV), also for both modes.



The bits supplied by the EPROM enable the EPLD to deliver the desired (digital) signals at its outputs: RGB, SV (V-sync), SHV (H-sync), CSC (or FSC, colour subcarrier) and L23 (WSS drive signal for PALplus). A 550-Hz audio test signal is obtained from the A11 line on counter IC4. The audio signal is passed directly to the output socket and to the RF modulator, while the other output signals from IC1 are processed by the PAL encoder, IC2. Apart from RGB and Sync signals, the output of the video generator also supplies CVBS (colour-video-blanking-sync, or composite video), and the S-VHS components C (chrominance) and Y (luminance). The UHF modulator receives the audio and CVBS signals, and enables the video generator to be connected to the antenna input of a TV set or a video recorder.

GENERATING PALPLUS

A condition for generating a test chart which is suitable for checking a PALplus TV set is that the colour subcarrier and the line frequency are related as set out in the standards (see inset on the PALplus format). In accordance with the PAL standard, the colour subcarrier frequency is 4.43361875 MHz, and the line frequency is 15,625 Hz. That gives a frequency ratio of

$$4{,}433{,}618.75/15{,}625 = 283.7516.$$

This unusual ratio is applied because it minimizes the risk of interference in the transmission of the modulated colour (C) and luminance (Y) components. In studios, the above ratio is achieved with the aid of a highly complex syncbox. Fortunately, it may also be done in a simpler way, using programmable ICs. The circuit splits the number 283.7516 into three parts: 284, −0.25 and +0.0016. 0.25×1 period of CSC means that each line first has to be shortened by 360°×0.25 =90°, or 56 ns shorter than 284 periods. The pulse generation is illustrated by the timing diagram in **Figure 3**.

The line frequency (also called horizontal frequency) is divided by two to give FH/2 (FH2 signal), i.e., 7.8125 kHz. The 8.86-MHz signal from quartz oscillator X2 (at the top in the drawing) is divided by two to give the colour subcarrier frequency, 4.43 MHz. During one clock period of the 8.86-MHz signal, FH2 changes the direction of the switching pulse edge. This effectively shortens the line duration by half a period of the 8.86-MHz signal, or a quarter period of the CSC signal. Now, what about the 0.0016 period per line? For a complete picture of 625 lines, this amount corresponds to one full period, or half a period (112 ns) per field (half-picture). The frame (full-picture) reset (RESET) lengthens the time by 225 ns. If, during this time, two additional FH2 edges are inserted (with otherwise non-switching equalization pulses), the time is reduced to +112 ns. During the other field, two FH2 edges are suppressed, giving +112 ns also. In the frame, CSC is thus subject to a phase shift of 180° for alternate lines, with identical picture contents for both fields.

3

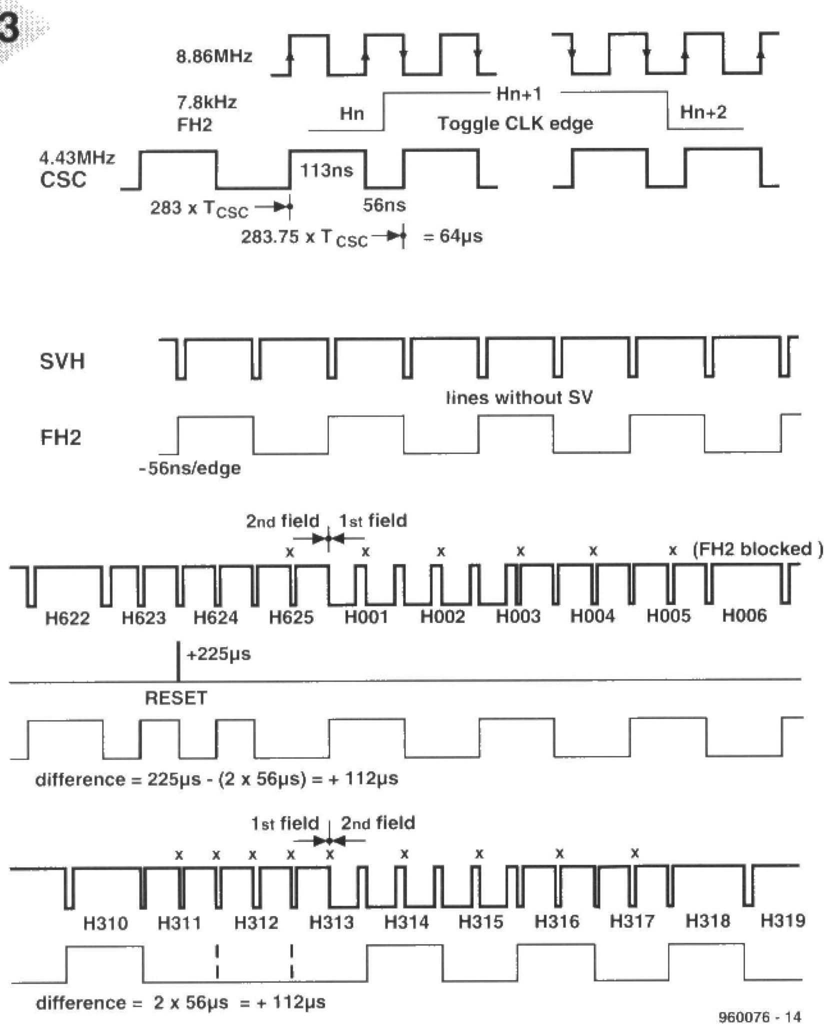


Figure 3. Timing diagram showing the horizonal timing. PALplus requires proper locking of the colour subcarrier to the line frequency.

As mentioned earlier on, the above satisfies an important requirement for the correct operation of PALplus. The only difference in the generation of this phase shift as compared with studio-grade syncboxes lies in the fact that 112 ns are added in one go to two picture lines, instead of being equally distributed over all lines in each field. Fortunately, because the duration error of these two lines occurs practically within the pre-equalization pulses before the raster sync pulses, no visible interference occurs with the line synchronisation. If this signal is used to trigger an oscilloscope, the otherwise always unstable colour burst can be synchronised, too. Provided you have a frequency meter with a 1-MHz reference (Droitwich or DCF77 locked), the correct offset for PAL systems may be checked as follows.

On a two-channel oscilloscope, channel A is set to 'TV line' triggering. On channel B, the 1-MHz reference is made to freeze by carefully adjusting trimmer C23 for the CSC signal. This works because 64 µs is an even-numbered multiple of 1 µs. A frequency meter calibrated with the same frequency reference should then indicate the CSC frequency as exactly 4.3361875 MHz.

It was already mentioned that the video generator uses a somewhat simplified PALplus encoding. Fortunately, a PALplus TV set will not notice the small errors. To begin with, the high-frequency component in the helper lines is not modulated. Apart from a short identification signal, these lines remain black. According to the standard, the CSC reference in line 23 should have a phase of 180°. In the generator, however, the colour yellow is used, having a phase shift of 167°. Fortunately, the non-black Y value does not cause problems. In the generation of the WSS signal, the maximum jitter of the 5-MHz oscillator (X1) amounts to some 200 ns, and can not be ignored. With the PALplus test charts, WSS is switched into place in line 23 in Camera mode, using the XINS signal (EPROM code 80h). The WSS signal is applied to the RGB inputs of the PAL encoder, IC2, via R11 and diodes D1, D2 and D3.

Next month's second and final instalment will discuss the VGA mode and the test charts. Construction, test and application of the video generator are also covered.

(960076-1)

MatchBox BASIC computer as data logger

750 sampled values in an EEPROM

1

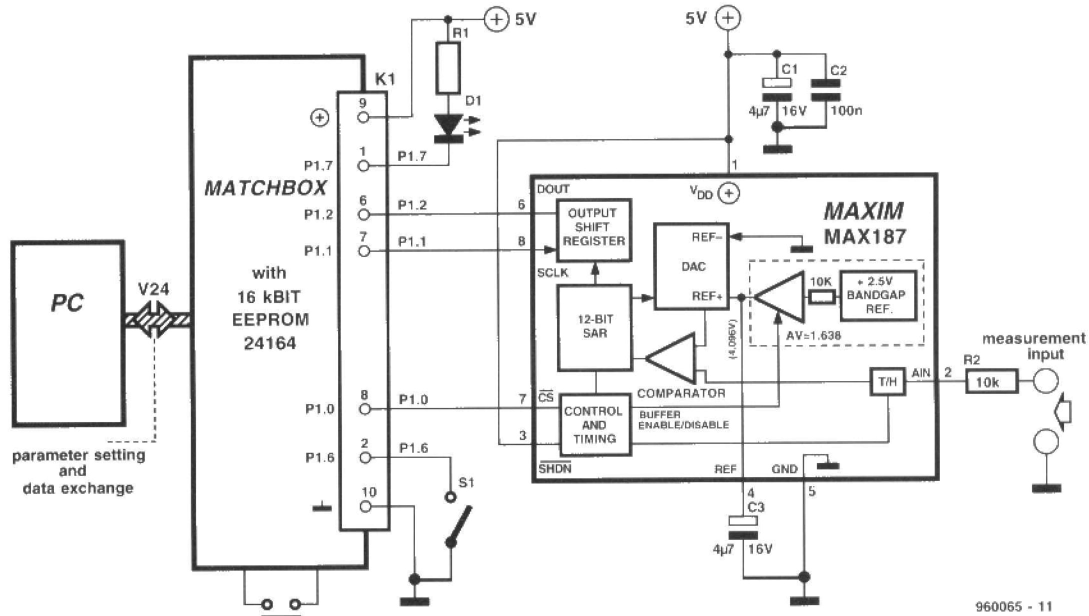


Figure 1. This simple extension circuit turns the MatchBox BASIC computer into a versatile data logger.

A data logger is a circuit which records, collects and stores measured values over a certain period of time. The MatchBox BASIC computer is a great starting point for such a system, because it only needs a small external A/D converter and a suitable program. The MatchBox data logger we present here is capable of storing up to 750 measured values.

Design by Dr. M. Ohsmann

Electronics test and measurement jobs often mean that you are on the road, that is, not in the safe and familiar surroundings of the laboratory or the workshop. The help of a data logger system is particulary valued if you wish to record a series of measurements at a certain location, and also need to take the measurement values home with you for examination, statistics or any

2

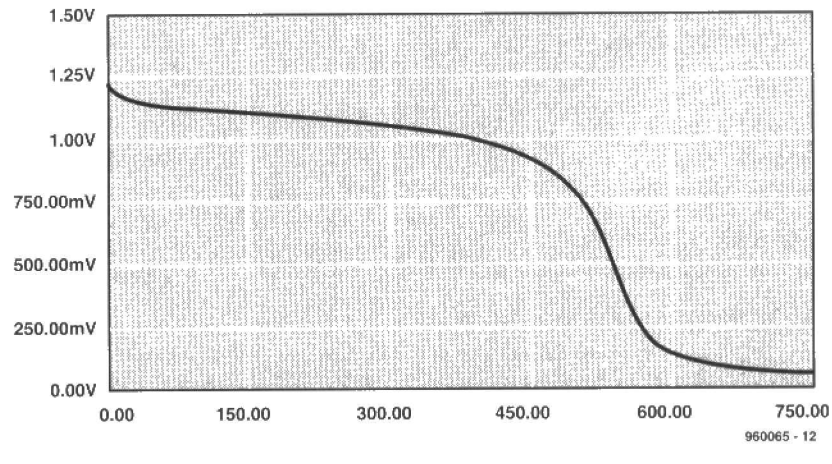


Figure 2. Example of a NiCd battery discharging voltage graph, as recorded by the data logger.

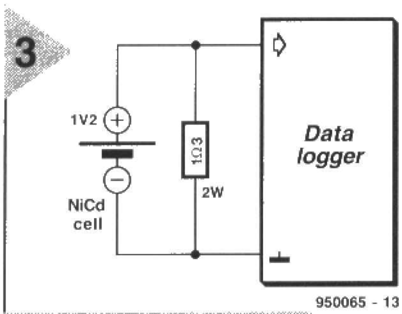


Figure 3. Circuit for the battery capacity test application.

form of analysis using a computer. The data logger, usually a small and low-cost device, uses fixed intervals to collect a large number of measured values in a memory. The computer is then able to read these values from the memory, and use them in a program.

As a matter of course, the data logger should have some intelligence to ensure that the measurement procedure is timely initiated and correctly finished. Here, these functions are carried out by a program running on the MatchBox BASIC computer (Ref. 1). The program controls a 12-bit serial A-D (analogue-to-digital) converter and enters each and every measurement value at the right address in the memory.

The measurement interval is defined beforehand in the laboratory or at home using the PC and the serial interface. Because the measurement values are stored in an EEPROM, the power supply may be switched off without problems once all samples are measured and collected. This obviates the use of a complex battery backup circuit.

BEFORE THE MEASUREMENT

The extension circuit that turns the MatchBox BASIC computer into a data logger is shown in **Figure 1**. A 12-bit A-D converter with serial output is connected to the MatchBox BASIC computer via port P1. The data logging process is started by pressing the switch connected to line P1.6. An LED, D1, enables the user to monitor the operation of the data logger. The PC is connected to the RS232 interface on the MatchBox BASIC computer. It essential that the MatchBox computer be fitted with a 16-kBit EEPROM (for example, an X24164 from Xicor). If not, you may not have enough memory capacity to store 750 values.

The circuit is easily built on a small

Figure 4. This program enables the MatchBox BASIC computer to act as a data logger.

4

```
; Project DATLOG1.MBL
; subject:
;     Matchbox Datalogger with MAX187
;
; 24C16 EEPROM program : about 512 bytes ,
;                  data     :  2048-512=1536 bytes   = 750 integer values
; 750 Values, 1 per     sec ->  > 12 minutes
;                1 per     min ->  > 12 h
;                1 per 10 min ->  > 5  days
;
RESOURCE IIC-EEPROM  0800H BYTES @05000H ;
RESOURCE 8051-IRAM    10H    BYTES @070H

BYTE COM CHR ;
INTEGER PTR,DUMP PTR ;
INTEGER EEPROM T ;
; for MAXIM conversion
INTEGER LOG MAX,K,value,Tcnt ;

INTEGER EEPROM LOG RAM[750] ;

ON INT GOSUB LOG DATA

  P1.7:=0 ; turn on LED

RESTART:
  PRINT('"0D"0A*>')                     ; send the PROMPT to RS232
  TIMER(0,0)                            ; stop  the timer
  Tcnt:=0                               ; counts time between samples
  FORMAT(D LENGTH=0 Z U r)              ; ok, simple decimal output
  LOG MAX:=750                          ; samples run from 0..LOG MAX
  WHILE P1.6=1 DO                       ; wait for KEY-pressed
    IF TSTC THEN                        ; if RS232 char then respond to it
      GOSUB COMMAND
     PRINT('"0D"0A*>')                  ; send prompt again
     ENDIF
    WHEND
  P1.7:=0 ;                             ; key is pressed, turn on LED again
  WHILE P1.6=0 DO                       ; wait for key release
    WHEND
P1.7:=1 ;; turn off LED, logging starts
START LOG:
  PTR:=0                                ; point to first memory
  SETBITS(INTena,TIMena)                ; enable timer interrupt
  TIMER(192,4800)                       ; start the timer
  PRINT('"0D"0ASTART T=',T,'"0D"0A')         ; print a start message via RS232
  WHILE TESTBITS(INTena) DO             ; while INTena is set, the datalogger is logging
    WHEND
  GOTO RESTART                          ; after logging restart with LED off


COMMAND:                                ; execute RS232 commands
  COM CHR:=GETC
  IF COM CHR='T' THEN                   ; time set command
    PRINT('T=') ;
    T:=GETDEC                           ; enter time between samples in seconds
    PRINT('"0DH"0AT=',T)                ; Echo (acknowledge)
    ENDIF
  IF COM CHR='D' THEN                   ; DUMP data command
    PRINT('DUMP, T=',T,'"0D"0A') ;
    DUMP PTR:=0 ;
    WHILE DUMP PTR<T45>GMAX DO
      IF TSTC THEN                      ; any CHAR aborts dump
        GOTO COMMAND
        ENDIF
      PRINT(DUMP PTR,' ',LOG RAM[DUMP PTR],'"0D"0A') ;
      DUMP PTR:=DUMP PTR+1
      WHEND
    PRINT('!') ;                        ; this says all data is dumped
    ENDIF
  RETURN

LOG DATA:
  P1.7:=0                               ; LED on flash
  Tcnt:=Tcnt+1                          ;
  P1.7:=1                               ; LED off flash
  IF Tcnt>=T THEN                       ; time between samples over ?
    P1.7:=0                             ; (make) long flash
    Tcnt:=0                             ; reset time between samples
    GOSUB READ MAXIM                    ; read in the AD converter
    PRINT(PTR,':',value,'"0D"0A')             ; printout to enable watch of LOGGING
    P1.7:=1
    LOG RAM[PTR]:=value                 ; store value
    PTR:=PTR+1                          ; increment memory pointer
    ENDIF

  IF PTR>LOG MAX OR P1.6=0 THEN
    PTR:=0                              ; end of RAM or key-hit stops LOGGING
```

piece of stripboard, which is connected to the Matchbox BASIC computer via connector K1. The board is then built into a small case. This results in a portable data logger which is capable of gathering data for hours on end, all alone, and only powered by a battery.

The A-D converter used is a type MAX187 from Maxim. It is capable of converting measurement values between 0 V and 4.096 V. If you wish to measure other voltage levels, then an appropriate voltage divider or a small preamplifier may have to be connected at the input of the MAX187.

The normal input voltage range is, however, perfect for measuring the discharging voltage of a rechargeable battery, to mention but an example. A graph that indicates the results of such a measurement session is shown in **Figure 2**. The relevant measurement set up is shown in **Figure 3**. Samples were recorded at 5-second intervals. After about 450 times 5 seconds, or about 40 minutes, the voltage drops rapidly, indicating that the battery is exhausted.

The program listed in **Figure 4** is sent to the MatchBox BASIC computer using the download utility which comes with the MBC software. The operation of the program is easily unravelled by referring to the comment with most instructions. Once the program is stored in the EEPROM on the MatchBox board, a terminal emulation program (like Procomm or Hyper Terminal) may be used to communicate with the data logger.

The procedure to program the interval between samples is as follows. Interconnect the PC and the MatchBox BASIC computer via the respective serial interfaces, then start the MatchBox. The data logger program should report with the *> prompt. Next, type **T** and then the number of seconds (0 to 30,000) which should elapse between the sampling instants. The data logger should then report again with its *> prompt.

LOGGING AND READING

To actually record measurement values, the PC is disconnected from the data logger. If you wish, you may switch off the MatchBox supply. Because the previously entered measurement interval is stored in EEPROM, this information is not lost. Next, you connect the measurement input of the data logger to the signal to be measured, and power up the MatchBox computer. LED D1 will light. Press S1 to start the measuring process. The data logger starts to record measured values as soon as you release the presskey. LED D1 lights briefly at a rate of about 1 Hz, and a little longer during the actual measurement. It goes out after all 750 measurements have been made. You may then switch off the MatchBox and take it back to the PC to enable the collected data to be read out.

```
      CLEARBITS(INTena)              ; stop DATA logging
      ENDIF
    CLEARBITS(TIMint)                ; signalise end of interrupt
    IRETURN

  ; The following subroutine reads the MAXIM 187 12-Bit AD converter
  ; connection of the MAX187:
  ;
  ; P1.1 : MAX187 CLOCK
  ; P1.0 : Max187 CS
  ; P1.2 : MAX187 DOUT
  ;

READ MAXIM:
P1.0:=1                              ; CS
P1.1:=0                    ; set clock line LOW
P1.2:=1                              ; we want port as input pin
P1.0:=0                    ; CS active
; the MAX187 is fast, so we need not wait
;WHILE P1.2=0 DO                     ; wait for MAX187-OUT line to become HIGH
;   WHEND
P1.1:=1                              ; clock
value:=0                             ; value holds the MAX conversion result
K:=11 ;                              ; read 12 bits
WHILE K>=0 DO
  P1.1:=0                            ; clock goes low
  value:=(value SHL 1)+P1.2          ; shift in the bit
  P1.1:=1                            ; clock goes high again
  K:=K-1 ;
WHEND ;
RETURN

END
```

5

```
DUMP, T=5
   0 1223
   1 1214
      .
      .
      .
749 46
750 46
!
```

Figure 5. Output format of the data collected by the data logger system (example).

The data logging operation may be re-started any time simply by pressing S1. While the data logger is measuring, it also transmits the currently read value via the serial interface.

Once reconnected to the PC, you start the MatchBox BASIC computer again. The unit should report with the *> prompt. Transmit the character **D** (for Dump) from the PC. The MatchBox will respond by returning all previously recorded data as illustrated by the example shown in **Figure 5**. The first line tells you the timing interval at which samples were captured. Then follow 751 lines, all containing measurement values. In the rechargeable battery example, the initial voltage (found in line 0) was 1,223 mV, while the final voltage (751st measurement result) was 46 mV. First, the number of the measurement is produced, then the measured value.

Measured values are in millivolts (mV). In the last line, the exclamation mark (!) marks the end of the measurement values. Using the terminal program running on the PC, these values may be stored in a file for processing later.

PROGRAM DESCRIPTION

The program that turns the MatchBox into a data logger is shown in **Figure 4**. It is not too long, and easily entered by typing it in. Store the program as an ASCII file on your PC. Unfortunately, the program is not available on disk through our Readers Services.

A few points may be noted about the program. The timing of the sampling process is arranged by the internal MatchBox timer, which is programmed (in lines 28 and 45) to generate an interrupt every second. The relevant MatchBox interrupt is enabled by line 44, so that the interrupt routine in lines 73 to 92 is selected once every second during the logging process.

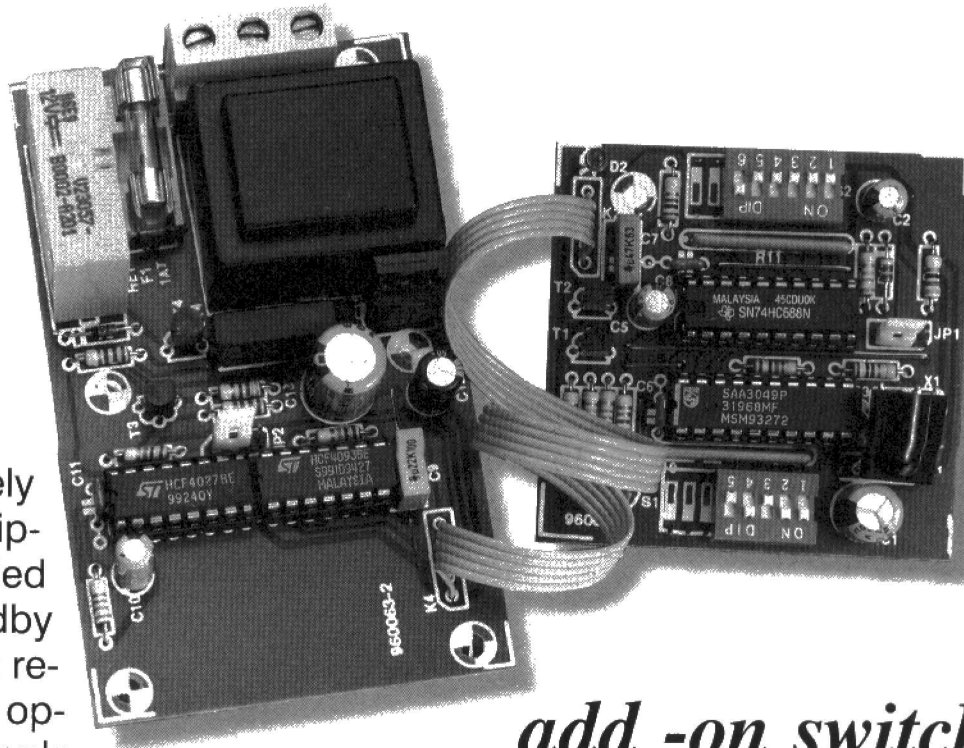
The program may be modified in many ways to suit individual requirements. You may, for example, decide to use the I²C compatible type PCF9591 A-D converter to enable data to be captured on four channels at a resolution of eight bits. The program should require only minor modifications to support this component. The procedure which reads data from the MAX187 may, of course, also be used for other MatchBox projects in which a 12-bit A-D converter is applied.

(960065)

Reference:

1. MatchBox BASIC computer, *Elektor Electronics* October, November, December 1995.

standby unit for TV economy



Infra-red remotely controlled equipment is provided with a standby mode in which it remains ready to operate at a simple command of a particular button on the remote control unit. In this mode, older television receivers can dissipate 20 W or more! The add-on switch described in this article can bring this figure down to about 1.5 W. It is simply inserted in the cable between the mains outlet and the equipment and operated by the existing infra-red remote control unit.

add -on switch for older TV receivers

Design by U. Reiser

If you are looking at new television receivers in the shops, you will probably notice that current models have a lower standby energy drain than their predecessors. Depending on the particular make, it varies between 3 W and 6 W. This is, no doubt, due to the many recommendations the Consumer Association has been making to the television industry over the past ten years or so. After all, this kind of wasted energy in a single household does not really amount to much, but the sum total in the United Kingdom must be colossal.

There are several ways of reducing this waste. You can finally do away with your old set and get a modern one. Or you can switch the set **off** completely after use. Or you can build the add-on switch described in this article, which, by pressing the standby button on the remote control unit isolates the set from the mains. Pressing any other button on the remote control unit switches the receiver on again. It should be borne in mind, however, that the circuit works only with infra-red remote control units that operate with the RC5 code or the older RESC80 code.

INFRA-RED RECEIVER

The circuit for the reception and decoding of the infra-red signals is very similar to that used in 'Infra-red controlled dimmer' published in the February 1995 issue of *Elektor Electronics*—see **Figure 1**.

The internal photodiode of IC_1 intercepts the infra-red signal from the remote control unit. The low-noise amplifier raises the signal to the level needed for further processing. The operating point of the amplifier is controlled by a current source, which also blanks out low-frequency signals.

The high immunity to interference of the IC is achieved by a bandpass filter tuned to the signal frequency.

After it has been amplitude-limited, the signal is demodulated and made available as serial information at the buffered output of the IC.

Network R_1-C_1 decouples the supply voltage with respect to the remainder of the circuit.

When its pin 11 is high, IC_2 decodes pulse-width modulated RESC80-coded signals; when this pin is low, the circuit decodes biphase-modulated RC5-coded signals appearing at the output

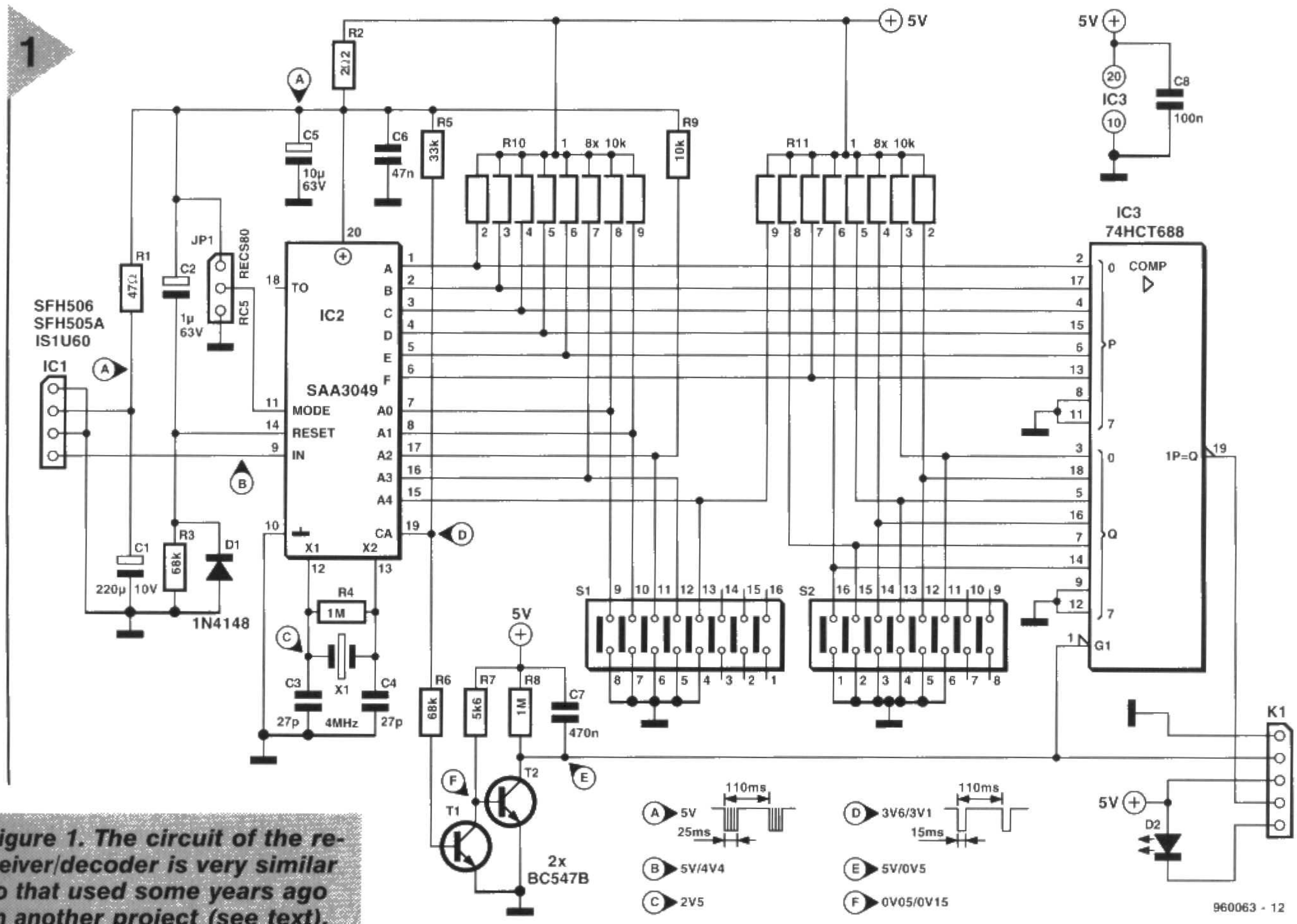


Figure 1. The circuit of the receiver/decoder is very similar to that used some years ago in another project (see text). The DIP switches enable equipment and address codes to be set.

of the infra-red receiver. In the decoding, a distinction is made between command data bits C_5–C_0 and system addresses S_4–S_0 (for details, see box).

Circuit IC_2 can operate in two modes: *Single System* and *Combined System*. In the combined-system mode (pin 19 low), a received system address is output at pins A_0–A_4. When pin 19 is high, as in the present circuit, the IC works in the single-system mode. Pins A_0–A_4 can then be used as inputs that may be programmed with jumpers. If the received address accords with that set with S_1, 15 ms long pulses (one for each data word) appear at pin 19. These pulses are converted by network T_1-T_2-R_8-C_7 into a continuous, low signal, which enables IC_3 and is also applied to the switching circuit (Figure 2) via K_1.

The frequency of the clock oscillator on board IC_2 is determined by crystal X_1.

Power-up network R_3-C_2-D_1 sets all data and address outputs simultaneously to high after the supply has been switched on.

The command code appears at outputs A–F. Since the standby switch must be turned off only with the standby button on the remote control unit, the command code must be preceded by a data selection. This is achieved with 8-bit comparator IC_3. If the word input at pins P_0–P_5 accords with the code set at Q_0–Q_5 with S_2, output P=Q goes low, which drives the switching circuit (Figure 2) via K_1. All this functions only, of course, when the signal at the CA pin of IC_1 enables the comparator.

SWITCHING STAGE

Two signals are applied to the switching circuit via K_1: the enabling signal from IC_1, which indicates a correctly received equipment address, and the signal from the comparator which indicates that the equipment address accords with command code 'standby'.

The switching stage in **Figure 2** evaluates the two signals that are used to drive bistable IC_{5b}, which holds the current state of the circuit until a new command is given with the remote control unit.

The output of the bistable is applied to relay Re_1 via buffer T_4. The relay connects the television receiver to, or disconnects it from, the mains, as the case may be.

For the television receiver to be switched off, both the address code and the command code must accord with the set address, whereas for it to be switched on again, the address code and a random command from the remote control unit suffice.

The requisite logic circuits consist of the gates in IC_4, which together form a Schmitt trigger/inverter that converts the negative pulses (both those at CA in IC_1 and P=Q in IC_3), delay network R_{12}-C_9, and bistable IC_{5b}. The delay network ensures that inputs J and K of the bistable have a defined level before the clock pulses are applied. Each and every operation of the buttons on the remote control unit results in a leading edge at the C(lock) input of the bistable. Provided that the levels at the set input (permanently to earth) and the reset input (after power-up also at earth potential) are equal, then, according to the level at inputs J and K, the bistable effects an action as shown in Table 1.

It is possible to choose between two

Logic table of the 4027

S	R	CLK	J	K	Q before CLK	Q after CLK
L	L	↑	H	L	0	1
L	L	↑	H	H	x	$\overline{Q}$
L	L	↑	L	H	1	0
L	L	↑	L	L	x	Q

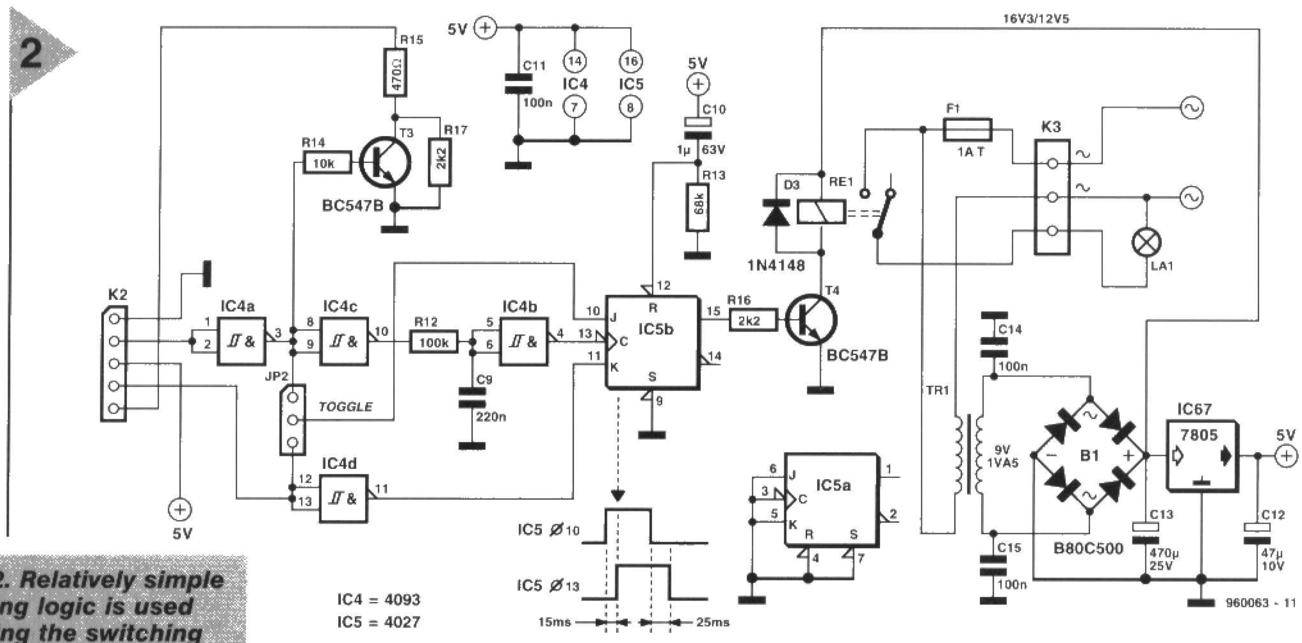


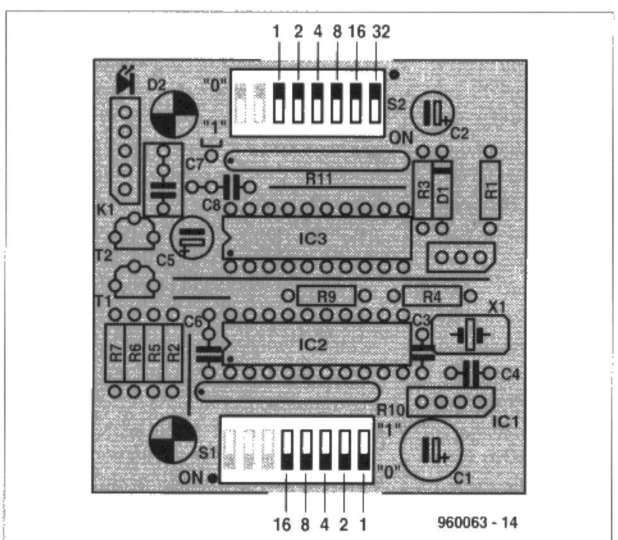
Figure 2. Relatively simple evaluating logic is used for driving the switching circuit.

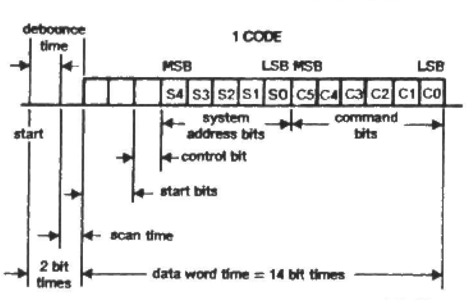
switching characteristics of the TV receiver by changing over jumper JP_2. If this is in the upper position, so that the J input of the bistable is connected to the clock, pressing any button (except standby) on the remote control unit causes the output of the bistable to go high, whereupon the relay is energized so that the television receiver is switched on. If in this condition the standby button is pressed, the output of the bistable changes state and the relay is deactuated, so that the television set is switched off.

When the jumper is in the lower position, the levels at the J and K inputs of the bistable are always mutually inverse, so that pressing the standby button **always** causes the TV receiver to be switched **off**, whereas pressing any other button on the remote control unit **always** causes the set to be switched **on**.

It is clear from the foregoing that

Codes for equipment and commands

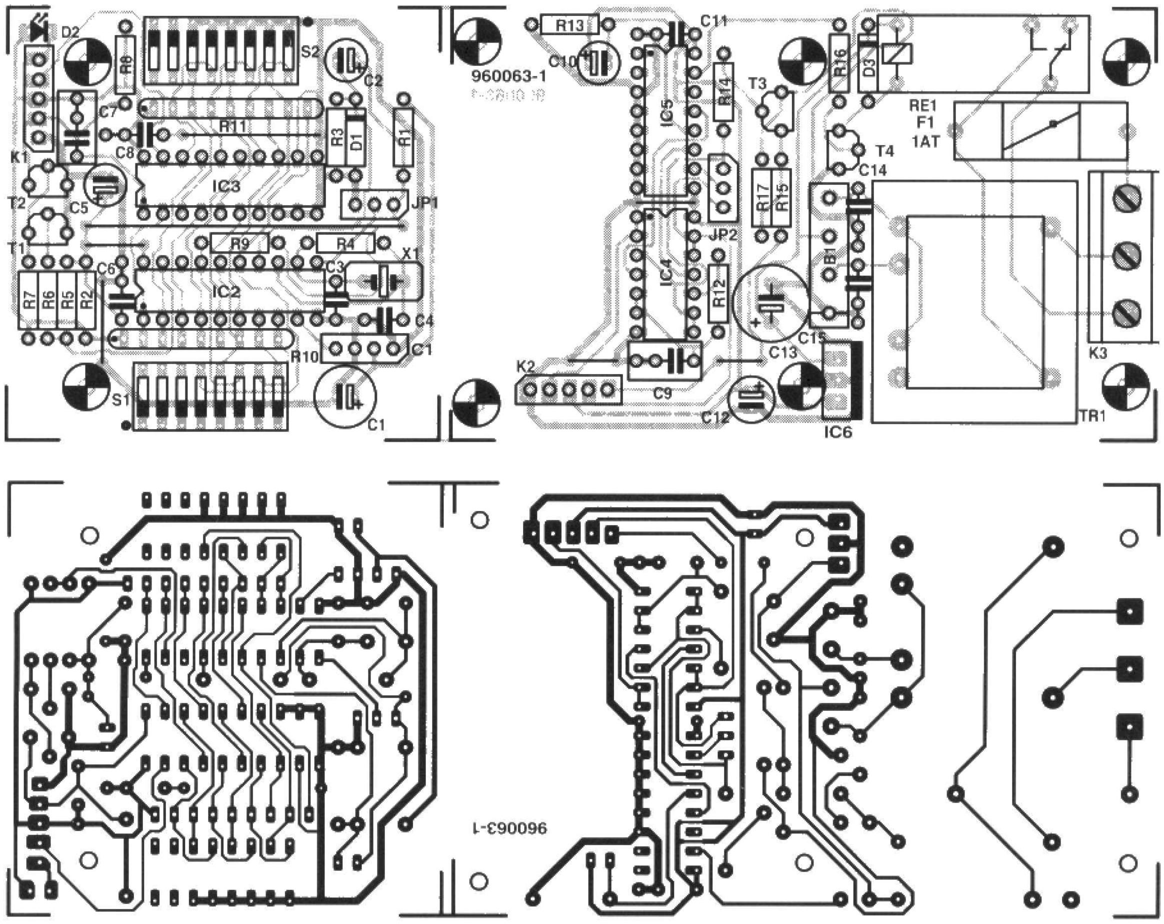




Address (S_1)	S_4–S_0	Equipment	Remarks
0	00000	TV1	TV receiver 1
1	00001	TV2	TV receiver 2
2	00010	VTX	teletext
3	00011		extension for TV1 and TV2
4	00100	LV	laser-vision
5	00101	VCR1	video recorder 1
6	00110	VCR2	video recorder 2
7	00111		for experimentation
8	01000	SAT1	satellite TV receiver 1
9	01001		extension for VCR1 and VCR2
10	01010	SAT2	satellite TV receiver 2
11	01011		for experimentation
12	01100	CD-video	CD-video player
13	01101		for experimentation
14	01110	CD-photo	CD-photo player
15	01111		for experimentation
16	10000	Preamp1	audio preamplifier 1
17	10001	Tuner	receiver/tuner
18	10010	Rec 1	analogue recorder
19	10011	Preamp 2	audio preamplifier 2
20	10100	CD player	CD player
21	10101	Combi	audio/recording system
22	10110	SAT	satellite audio receiver
23	10111	Rec 2	digital recorder
24	11000		for experimentation
25	11001		for experimentation
26	11010	CDR	writable CD
27–31			for experimentation

Address (S_2)	C_5–C_0	Command
0–9	0–9	
12	001100	Standby
61	111101	System standby

2



the jumper should be placed in the position that accords with the switching characteristics of the TV receiver.

The circuit based on T_3 drives D_2 in the receiver/decoder section. This LED flashes when an equipment address is received correctly.

Figure 3. The printed-circuit board for the standby unit should be cut into two before any work is done.

The conventional power supply (see Figure 2) provides a +5 V power line. In the quiescent state, the standby unit draws a current of only 9 mA. Note, however, that the short-circuit-proof mains transformer has a dissipation of 0.9–1.3 W.

In normal operation, the current drain increases by some 40 mA, mainly because of the relay.

The relay contacts are protected by fuse F_1, so that, in case of a short-circuit in the TV set, the relay contacts do not burn out. The fuse must, of course, be matched to the current drawn by the TV receiver. If desired, the fuse may be replaced by a thermal switch,

PARTS LIST

Resistors:
R_1 = 47 Ω
R_2 = 2.2 Ω
R_3, R_6 = 68 kΩ
R_4, R_8 = 1 MΩ
R_5 = 33 kΩ
R_7 = 5.6 kΩ
R_9 = 10 kΩ
R_{10}, R_{11} = 8×10 kΩ array
R_{12} = 100 kΩ
R_{13} = 68 kΩ
R_{14} = 10 kΩ
R_{15} = 470 Ω
R_{16}, R_{17} = 2.2 kΩ

Capacitors:
C_1 = 220 μF, 10 V, radial
C_2 = 1 μF, 63 V, radial
C_3, C_4 = 27 pF
C_5 = 10 μF, 63 V, radial
C_6 = 47 nF
C_7 = 22 nF
C_8 = 100 nF
C_9 = 220 nF
C_{10} = 1 μF, 63 V, radial
C_{11}, C_{14}, C_{15} = 100 nF
C_{12} = 47 μF, 10 V, radial
C_{13} = 470 μF, 25 V, radial

Semiconductors:
D_1, D_3 = 1N4148
D_2 = low-current LED, red
T_1–T_4 = BC547B

Integrated circuits:
IC_1 = IS1U60, SFH506-36 or SFH505A
IC_2 = SAA3049
IC_3 = 74HC688 or 74HCT688
IC_4 = 4093
IC_5 = 4027
IC_6 = 7805

Miscellaneous:
JP1, JP2 = 3-way jumper and plug
K1, K2 = 5-way pcb connector with screw terminals, pitch 5 mm
K3 = 3-way pcb connector with screw terminals, pitch 7.5 mm
X1 = quartz crystal, 4 MHz
S1 = 5-way dil switch for board mounting (see text)
S2 = 6-way dil switch for board mounting (see text)
Re1 = relay, 12 V, 1 change-over contact
Tr1 = mains transformer, 9 V, 1.5 va, e.g. Velleman 1090018M or 2090018M (from Maplin)
B1 = rectifier B80C500
F1 = fuse holder for board mounting with 1 A slow fuse (see text)
Enclosure 120·65·65 mm, preferred OKW A-90 21 165 (OKW Enclosures Ltd, 3 Manor Court, Segensworth Business Park, Fareham PO15 5TH; telephone 01489 583858; fax 01489 583836)

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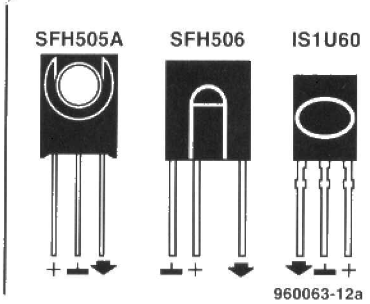

Figure 4. The IR sensor may be one of various types, some of which are shown here.

which, unlike a fuse, does not have to be replaced after a short-circuit in the TV set.

CONSTRUCTION

The standby unit is best built on the printed-circuit board shown in **Figure 3**. This board should be cut into two to provide a section for the receiver/decoder circuit and another for the switching circuit (and power supply).

It is advisable to use sockets for the various ICs, except the voltage regulator).

Multiple electronic DIP switches S_1 and S_2 are 5-position and 6-position versions respectively, but the board has space for (more easily obtainable) 8-position versions. The devices should be located as shown in the introductory photograph. Each switch section provides a logic 1 when its lever is in the ON position – the LSB is always at the right of the device.

If the standby unit is intended to control one equipment only, the DIP switches may be replaced by relevant wire bridges. Since both switches are provided with pull-up resistors, a closed switch or, as the case may be, a wire bridge signifies a logic 0 at the input.

The standby unit should preferably be fitted in the plug-in PSU box specified in the parts list. Particular attention should be paid to the insulation of the various interconnecting wires, which can be clearly seen in the introductory photograph.

The receiver/encoder board and the switching board must be sandwiched together with the aid of non-metal screws, nuts and spacers of suitable length.

CALIBRATION

For the calibration, a multimeter and a logic probe are required. When IC_1 senses an infra-red signal, its output shows a definite level, so that the collector of T_2 is low. When both addresses have been set correctly, pressing the standby button on the remote control unit should result in pin 19 of IC_3 going low. Trace the two signals from the input up to the relay.

If the delay between the clock and the J input of bistable IC_{5b} is insufficient, increase the value of C_9 to 330 nF. This aids the stability of the data transfer, but also makes it necessary for the remote control buttons to be pressed (relatively) rather longer.

Note that, owing to safety regulations, the LED and IC_1 must NOT protrude through the enclosure, but must be covered by a small sheet of perspex fixed inside the case.

Needless to say, since the unit carries mains voltage, great care must be taken in its construction and assembly.

USAGE

When everything works correctly, the boards have been screwed into place, IC_1 has been bent as shown in the photograph, the enclosure may be closed and the standby unit is ready for use.

[960063]

ELEKTOR		▢
230V ~	50Hz	
No. 960063		
F = 1A T		

In passing ...

Sometimes you wonder how manufacturers can produce certain items for the prices charged in the shops and survive. For instance, our technical department may be struggling to design, say, a digital thermometer, whose specification stipulates that the total of its parts must not cost more than £ 15. Then, out shopping one Saturday or Sunday, you see a ready-made digital thermometer in a shop for £ 8·95. How is it done? All designers know that for that kind of money you can just about buy the display and the associated control IC from your usual retailer or mail order firm.

Of course, it is not just the price of the item, there's also the fun and satisfaction in making it yourself. And in the end, of course, you make a much better thermometer than that cheap thing in the shop. If you ever open such a cheap item, you immediately see all the shortcuts used in its making. A flimsy board; no ic sockets, and if you press rather too hard against the display, its digits may disappear.

But some prices are really out of this world. A little while ago, a fairly large mail order firm offered in an advertisement an electric sander for £ 6·25. If you deduct the vat and the (small?) profit, you ask yourself how anybody can make such an item for only a few pounds. OK, it was probably made in a third-world country where people (are made to) work for next to nothing. It is depressing to read that in, for instance, Bangladesh the average annual family income is $50.00!

These low prices are not only a social problem, but they also damage the environment. After all, next time my sander (which originally cost £ 27·95) breaks down, I will not dream of having it repaired – I'll put it on the scrap heap, which gets bigger and bigger, and buy a new one for £ 6·25.

[HB - 965097]

LM3420-xxx

controller for Li-ion battery chargers

As described elsewhere in this issue, lithium-ion batteries are among the newest on the market. Because of their low weight, however, they are particularly suitable for use in small portable computers and mobile telephones. Owing to some of their properties, these batteries are, however, not compatible with current-generation chargers for NiCd and NiMH batteries. Several special ICS are already on the market.. In this article, the Type LM3420-xxx charging controller from National Semiconductor is described.

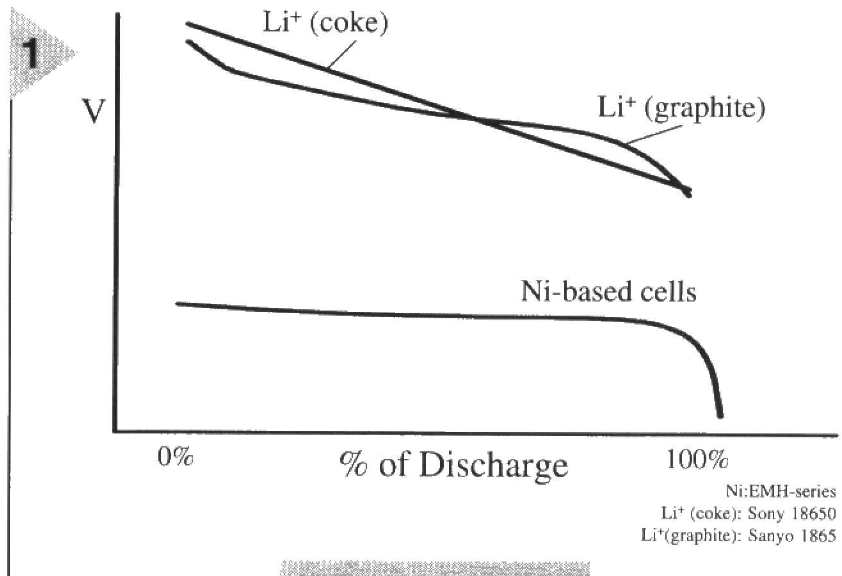

Figure 1. Discharge/ charging characteristics of a Li-ion battery with coke and graphite electrodes

Some pundits in the electrochemical industry reckon that over the next few years lithium-ion (Li-ion) batteries may well gradually replace nickel-cadmium (NiCd) and nickel-metal-hydride (NiMH) batteries. Currently, these new batteries are still three to four times as expensive as NiCd and NiMH systems. Nevertheless, because of their high energy density, good charge retention, and lower weight than NiCd batteries, they have already started to find their way into the more sophisticated laptop computers and mobile telephones.

The current generation of Li-ion batteries are claimed to have a life of 1200 cycles, a self-discharge factor of 8% per month (compared with 15% in NiCd and 25% in NiMH systems), and an energy density of 90– 125 W h kg^{-1} or 210–250 W h dm^{-3}, which is 3–4 times better than that of NiCd batteries. A claimed environmental advantage of the new batteries is their use of a non-aqueous liquid electrolyte of lithium salt dissolved in an organic solvent mixture.

CHARGING PROCESS

Li-ion battery systems must be charged in a quite different way from other types of secondary battery. Fortunately, the discharge curve of Li-ion batteries is rather steeper than that of NiCd and NiMH batteries, which makes it possible for a clear relationship between terminal voltage and state of charge to be established—see **Figure 1**. The e.m.f. of a fully charge Li-ion battery (with petroleum-coke anode, currently the most frequently used anode material) is 4.2 V. Up to this voltage, the battery is charged with constant current at the 1C rate. When that potential is reached, charging changes to constant voltage and gradually reducing current. The constant voltage must be within ±1% of the e.m.f. If this condition is not met, the battery will not become fully charged and thus not attain its full capacity.

This strict requirement makes charging control essential. Currently, very suitable controllers are the LM3420-4.2, LM3420-8.2. and LM3420-12.6 from National Semiconductor. The numbers following the hy-

Based on a National Semiconductor application

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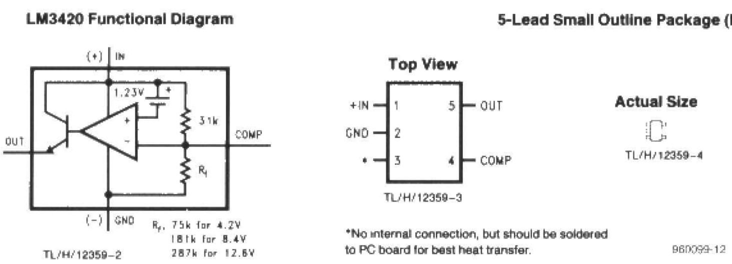

Figure 2. Internal circuit and pinout of the LM3420-xxx.

phen indicate the e.m.f. of the battery they should be used with. These integrated circuits are available in two versions: A, which guarantees a tolerance of the charging voltage of 0.5 per cent at 25 °C and 1 per cent over the temperature range; and B, which ensures tolerances twice those of the A version. They are housed in 5-pin SOT-23 cases and are, therefore, eminently suitable for inclusion in intelligent battery systems.

The tiny enclosure of the LM3420-xxx shown in **Figure 2** contains a compensated operational amplifier, a bandgap reference voltage source, an n-p-n output driver transistor and a temperature-compensated potential divider.

The output of the open-emitter transistor can provide a current of up to 15 mA.

The inverting input of the op amp, COMP, may be driven by an external frequency compensation circuit.

The balanced precision voltage source compensates for the temperature drift of the device to ensure tolerances of the charging voltage of 0.5 per cent or 1 per cent, depending on the version of the device.

The LM3420-xxx is a shunt regulator, normally fitted in the negative feedback loop in the charger, where it carries out both reference and control functions.

The regulated voltage at the battery terminals is measured between inputs IN and GND. If the measured voltage is lower than the nominal potential, V_{REG}, the OUT(put) pin does not provide current. Current will only be provided when the potential at the IN pin reaches the nominal value.

The output current may be used to drive a device in the feedback loop, such as an optoisolator, or a power device such as a linear or shunt regulator which holds the output voltage at the nominal level.

In some applications, even under normal operating conditions, the potential at the IN pin may be higher than the nominal value, but it must never exceed the maximum level of 20 V. Additional external current limiting may be used to restrict the current from the OUT(put) pin to a maximum value of 20 mA.

The external capacitor between the COMP and OUT pins stabilizes the charging control circuit and should have a value of 0.01–0.1 µF.

The nominal voltage of the LM3420-xxx may be reduced by con-

Typical values

Input voltage, V_{in}	*20V (max)*
Output current, I_o	*15 mA (20 mA max)*
Dissipation, P	*300 mW*
Ambient temperature range	*–40 °C to +85 °C*
Junction temperature	*–40 °C to +125 °C (150 °C max)*

Electrical characteristics of LM3420A-xxx (T_j = 25 °C, $V[IN] = V_{REG}$, V_{OUT} = 1.5 V)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{REG}	Nominal voltage	-4.2A, I_{OUT} = 1 mA	4.179	4.2	4.221	V
		-8.4A, I_{OUT} = 1 mA	8.358	8.4	8.442	V
		-12.6A, I_{OUT} = 1 mA	12.537	12.6	12.663	V
		-4.2A, I_{OUT} = 1 mA, full temp. range	4.158	4.20	4.242	V
		-8.4A, I_{OUT} = 1 mA, full temp. range	8.316	8.4	8.484	V
		-12.6A, I_{OUT} = 1 mA, full temp. range	12.474	12.6	12.726	V
	V_{REG} tolerance	I_{OUT} = 1 mA		0.5	1.0	%
I_q	Quiescent current	I_{OUT} = 1 mA		85	110	µA
G_m	Transconductance $\Delta I_{OUT}/\Delta V_{REG}$	I_{OUT} = 20 µA...1 mA, V_{OUT} = 2 V	1.3	3.3		mA/mV
		I_{OUT} = 1...15 mA, V_{OUT} = 2 V	3.0	6.0		mA/mV
A_V	Voltage amplification $\Delta V_{OUT}/\Delta V_{REG}$	V_{OUT} = 1 V ... (V_{REG}-1.2 V), R_L = 200 Ω	550	1000		V/V
		V_{OUT} = 1 V ... (V_{REG}-1.2 V), R_L = 2 kΩ	1500	3500		V/V
V_{SAT}	Output saturation	$V(IN) = V_{REG}$ + 100 mV, I_{OUT} = 15 mA		1.0	1.2	V
I_L	Output leakage current	$V(IN) = V_{REG}$ - 100 mV, V_{OUT} = 0 V		0.1	0.5	µA
R_f	Internal feedback resistance	-4.2	56	75	94	kΩ
		-8.4	135	181	227	kΩ
		-12.6	215	287	359	kΩ
E_n	Output noise level	I_{OUT} = 1 mA, f = 10 Hz...10 kHz, -4.2			70	$µV_{RMS}$
		I_{OUT} = 1 mA, f = 10 Hz...10 kHz, -8.4			140	$µV_{RMS}$
		I_{OUT} = 1 mA, f = 10 Hz...10 kHz, -16.8			210	$µV_{RMS}$

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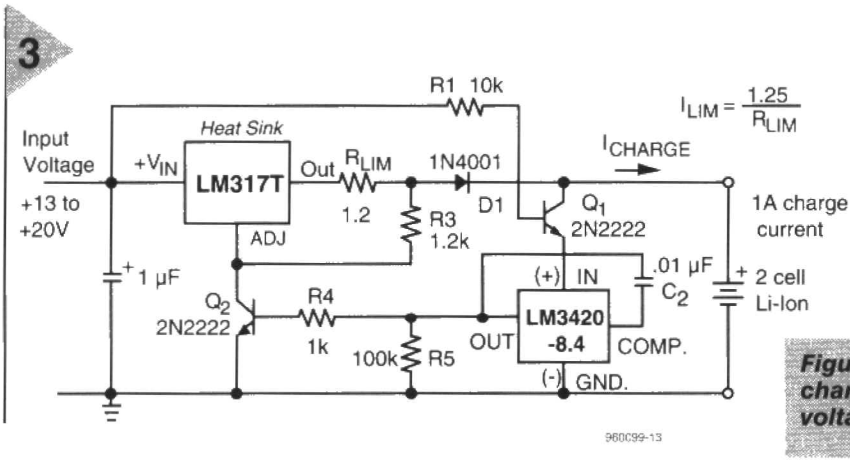

Figure 3. Simple charger with linear voltage regulator.

necting an external resistor, R_{CG}, between the COMP and GND pins, or increased by connecting a resistor R_{CI} between COMP and IN. In this way, the nominal voltage may be altered by ±10 per cent, disregarding the effect of drift caused by temperature changes. The value of the resistors (in Ω) is given by

LM3420-xxx
$R_{CG} = [53\times10^3/(U_n/U_o-1)]-75\times10^3$
$R_{CI} = 22\times10^3/U_o/U_n-1)$

LM3420-8.4
$R_{CG} = [154\times10^3/(U_n/U_o-1)]-181\times10^3$
$R_{CI} = 26\times10^3/U_o/U_n-1)$

LM3420-12.6
$R_{CG} = [259\times10^3/(U_n/U_o-1)]-287\times10^3$
$R_{CI} = 28\times10^3/U_o/U_n-1)$

where U_o is the output voltage and U_n the nominal voltage.

APPLICATIONS

Two typical applications will be looked at in some detail. The first is a constant current/constant voltage regulator and the second is a shunt regulator based on an LM2575ADJ, which was reviewed in this magazine as long ago as October 1991.

The circuit in **Figure 3**, which operates with 13–20 V charging voltages, is intended to charge an LM3420-8.4 battery with a constant current of 1 A. At the start of the charging process, when the battery e.m.f. is lower than 8.4 V, the output of the LM3420-8.4 does not provide drive for transistor Q_2. Since the transistor is then cut off, the Type LM317T variable, linear regulator functions as a constant-current source. The voltage regulator provides a drop of 1.25 V across R_{LIM}, so that the constant current, $I_{LIM} = 1.25/R_{LIM}$.

Transistor Q_1 breaks the link between the battery and the LM3420-8.4, so preventing the battery being discharged (at a current of 84 µA) via the charging controller

When charging takes place, the transistor is driven into saturation, so that the collector-emitter voltage, U_{CE} is only 5 mV.

Diode D_1 has a similar function: it prevents a current flowing from the battery through the voltage regulator. The total reverse current is well below 1 µA.

When the battery is being charged, its e.m.f., monitored at the IN pin of the LM3420-8.4, rises gradually. The charging controller reacts when the e.m.f. reaches 8.4 V by providing a current to the base of Q_2. This transistor begins to conduct and controls the potential at the ADJ pin of the LM317. The regulator then holds the e.m.f. at a level of 8.4 V, while the current is adapted to the state of charge. When the battery reaches its nominal capacity, the current has dropped to a very low level.

The shunt regulator circuit in **Figure 4**, which operates with charging voltages of 11–30 V, also provides a virtually constant current until the battery e.m.f. has been reached, upon which it switches to constant-voltage operation. It consists of two discrete feedback branches that are combined at the FB pin of the regulator.

The charging current is sensed by a 0.1 Ω shunt resistor. The resulting voltage drop across the resistor is magnified by differential amplifier IC_1 and applied to the feedback input of the LM2575 via D_2. The amplifier is arranged so that the charging current cannot exceed 1 A.

The battery e.m.f. is monitored by the LM3420-8.4 directly at the battery terminals. As long as this voltage is lower than 8.4 V, the output transistor is cut off, so that the regulator has no effect at the FB input. As in the earlier example, this situation changes when the e.m.f. reaches 8.4 V: the voltage remains constant, while the current gradually drops to zero.

Since the efficiency is very good – 80 per cent – the small dissipation in the regulator does not need a heat sink.

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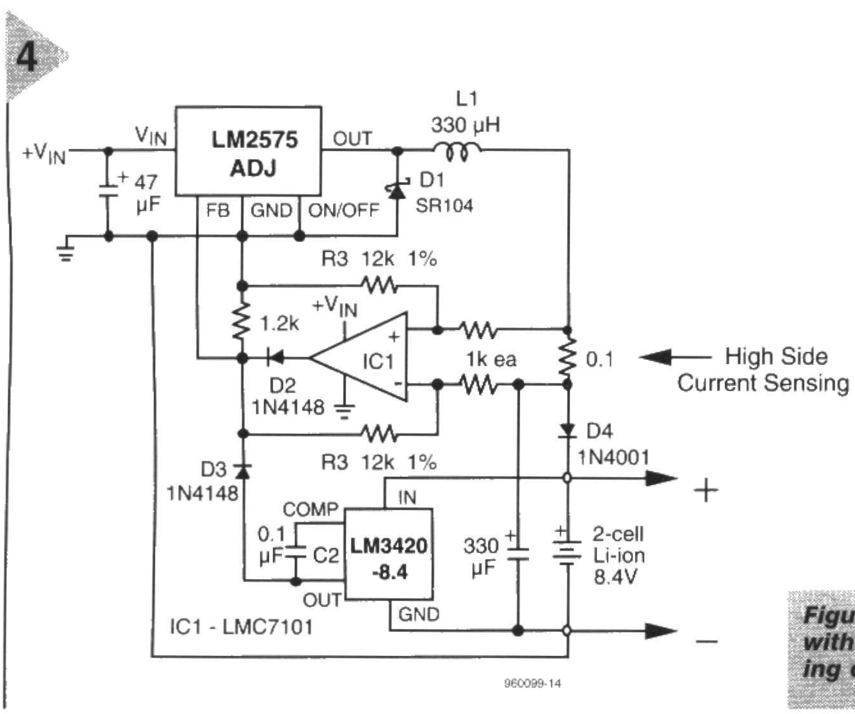

Figure 4. 1-A charger with simple switching circuit.

References:

Data sheet 'LM3420-4.2, LM3420-8.4, LM3420-12.6 Lithium-Ion Battery Charge Controller'; National Semiconductor, March 1996.

'LM3429 Lithium-Ion Battery Charge Controller Applications'; National Semiconductor.

simple infrared detector

makes infrared light audible

Although the human eye is unable to detect infrared light, this kind of light is emitted by many apparatus around us in everyday life. In a number of cases it may be useful or interesting to be able to detect and prove the presence of infrared light. The present circuit is perfect for that purpose. It is based on a special integrated circuit which contains an IR irradiance to frequency converter. In other words, the converter's output frequency provides an indication of the measured light intensity. A very handy and simple circuit!

Design by K. Schönhoff

The human eye is a marvellous example of biophysical ingenuity. With the help of dedicated brain sections, light beams perceived by our eyes are translated into colours and images. The exact operation of this process is quite complex, and explanations with various levels of difficulty may be found in biology textbooks. The fact that matters to us is that colours are perceived because objects reflect light with certain wavelengths only. The colour red, for example, is caused by light with a wavelength of about 700 nm (1 nm $=10^{-9}$ m), and blue, by light with a wavelength of about 400 nm. These two wavelengths are, roughly, the bounds of the spectrum which is visible to the human eye.

The sun and many other light sources in and around the home also produce light with a wavelength which is outside the 400-700 nm spectrum that can be seen by the human eye. Infrared light, for example, with a wavelength of about 1,000 nm, is frequently used for all kinds of remote control, as well as for cordless links between computers and peripheral devices like printers. Other sources of 'invisible' infrared light include bulbs and tube lighting. The laser in your CD player, too, emits light which is in the near-infrared range (approx. 780 nm).

Checking the operation of a faulty or at least suspect remote control is not so simple because you can not see the light the unit is supposed to emit. In such cases, the infrared detector described here may prove a very useful test device. The circuit consists of just five components plus a battery and a switch.

Light intensity to frequency conversion

How is infrared light detected? Well, a number of semiconductor manufacturers supply sensors with a window that passes light with a certain wavelength only. Here, a sensor is applied which responds to infrared light with a wavelength of 900 nm. The sensor, a type TSL245 from Texas Instruments, also converts the measured light intensity (irradiance) into a frequency which is within the audible range. A simple buzzer enables this frequency to be actually heard. The frequency of the tone you hear is an indication of the measured light intensity: the tone becomes higher as the measured intensity increases, and lower as the IR light intensity drops.

Practical circuit

The full circuit of the simple infrared detector is shown in **Figure 1**. The only active component is the TSL245, which contains the above mentioned intensity to frequency converter. Pins 1 and 2 of the sensor are connected to the supply voltage. Here, a pair of 1.5-volt batteries is used to power the circuit. Switch S1 acts as the on/off switch — if battery economy is an issue, then the

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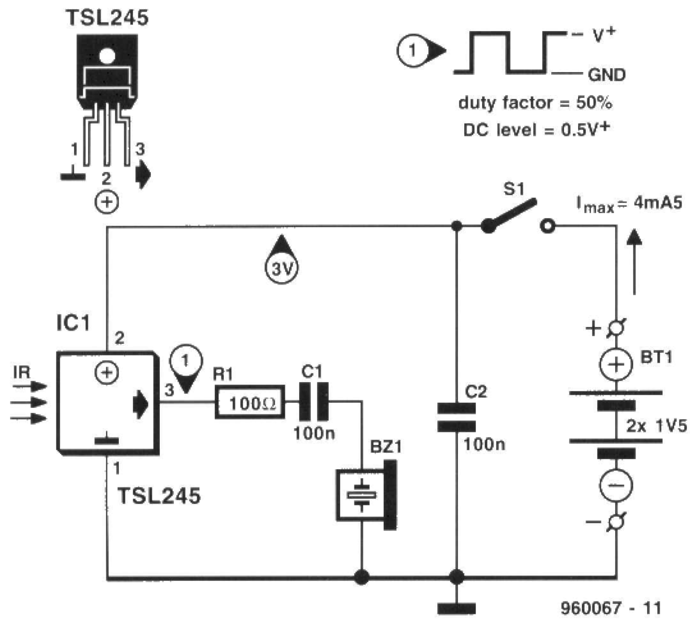

Figure 1. The circuit of the simple infrared detector consists of just five components, a switch and a pair of batteries.

switch may be replaced by a push-button. The output of the sensor, pin 3, produces the audible frequency. It is connected to a piezo buzzer via a resistor and a capacitor. The capacitor, C1, prevents direct current flow through the buzzer, while the resistor, R1, suppresses oscillation tendencies at the output of the IC. The only remaining capacitor in the circuit, C2, serves to decouple the supply line for RF signals.

Current consumption of the circuit is a modest 4.5 mA. That allows a pair of batteries to be used for a long time, provided, of course, you do not forget to switch off the detector when it is not used.

Construction

The circuit is so simple that it is really a waste of time and materials to design and etch a printed circuit board. The easiest way to build the detector is probably inside a small enclosure which has room for the buzzer and the batteries. Drill a hole in the case where the buzzer is fitted, and another hole for the sensor lens in the front panel. Another hole is required for the on/off switch. Having secured the sensor and the buzzer with a drop of glue, the three other components may be soldered to the relevant terminals. Although they are fitted 'in the air', the solder joints will give these parts sufficient support. Next, use short lengths of light-duty wire for the supply connections inside the case. Fit the batteries, and the infrared detector is ready for use.

Something wrong?

If the circuit does not work spot-on, there is, fortunately, not much to contend with or investigate to solve the problem. After all, there are only four components!

Start by checking all connections, and make sure the sensor is connected the right way around.

If everything appears to be all right, measure the supply voltage across pins 1 and 2 of the sensor (switch closed). This voltage must equal the battery voltage (approx. 3 V).

If the voltage is present, two things may be wrong: either the sensor or the buzzer is defective. The latter may be replaced by a crystal earpiece for a short test. If you still do not hear a tone, the sensor is likely to have 'died' from overheating.

Practical use

The infrared detector is simple to use. Direct the sensor to a possible source of infrared light, and close the switch. A tone will be audible if the source emits infrared light. Infrared remote controls may be tested by holding the detector in front of the control and then pressing a key. The modulation is audible as a kind of rattle. Bulbs and fluorescent lighting, too, produce infrared waves. If you hold the detector between a computer and a printer which communicate via an IRDa link, you can hear the bits whooshing past when a printing job is in progress.

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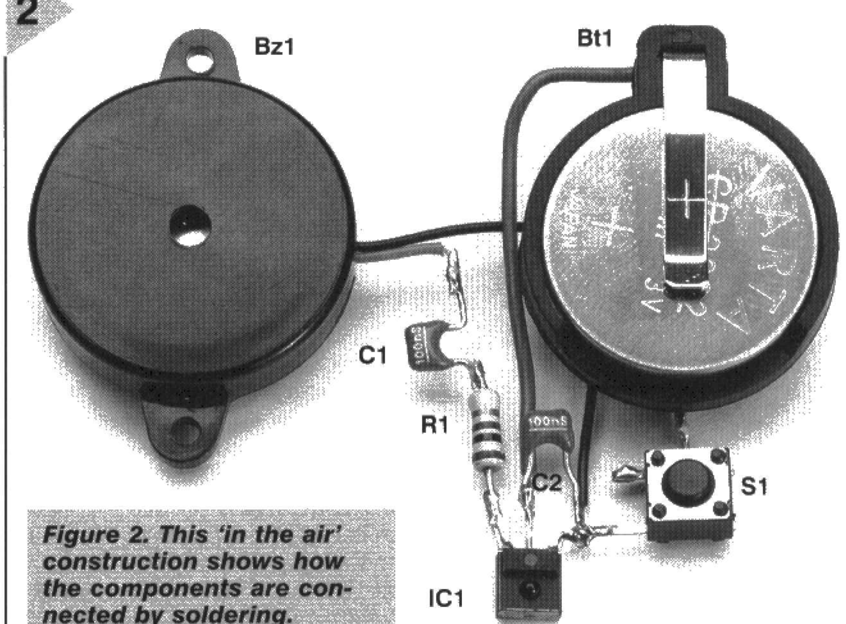
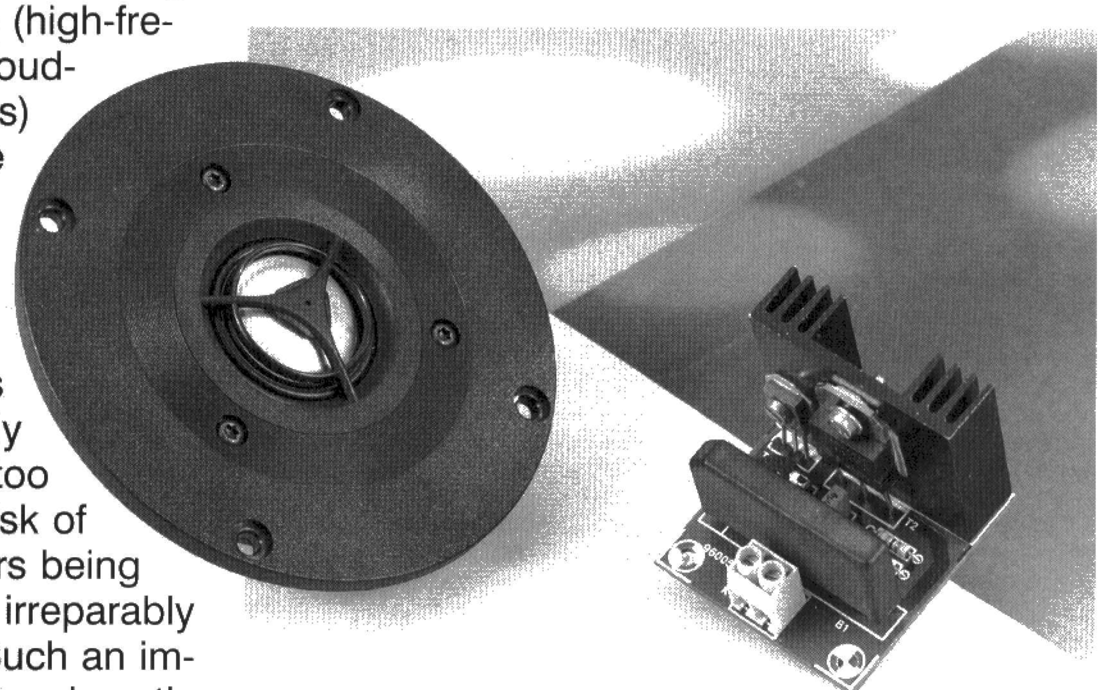


Figure 2. This 'in the air' construction shows how the components are connected by soldering.

a.f. power limiter

protects tweeter

Owing to their relatively low rating, tweeters (high-frequency loudspeakers) form the weak link in an audio system. If the volume is suddenly turned up too high, the risk of the tweeters being damaged irreparably is high. Such an impetuous and costly mistake, can, however, be avoided in two different ways. The first is to curb your desire to turn up the volume to levels that the loudspeakers cannot handle. The second is to build the power limiter presented in this article...it's much safer than controlling yourself when you're adjusting the volume of your beloved audio system.



Design by T. Giesberts

There will be many readers who, after reading the introduction to this article, will say that this does not concern them. They have a 100 W amplifier and the loudspeakers are also rated at 100 W. So, nothing can go wrong. Really?

Unfortunately, things can go wrong, since the rating given by the loudspeaker manufacturers is true only for *average* music signals. In arriving at this rating, account is taken of the fact that the energy contained in music signals is strongly dependent on frequency. Of the power delivered by the output amplifiers roughly 75 per cent is applied to the woofers (low-frequency loudspeakers), 25 per cent to the mid-frequency loudspeakers, and only 5 per cent to the tweeters. This means that of the power output of 100 W only about 5 W is applied to the tweeters.

Equally unfortunately, not all music signals are average. For in-stance, in the case of synthesizer music it can happen that a sudden burst of high-frequency music is produced, which at that instant contains more than half the total emitted energy. This means in this example that some 50–60 W of music power is applied to the tweeters instead of the *average* 5 W. Many tweeters just cannot cope with this sort of power.

There is yet another aspect concerning the specified rating of tweeters. Although in the case of woofers and mid-frequency speakers the 'true' rating is given by the manufacturers, this is not so in the case of tweeters. For these units, the specified rating applies only if they are used with a cross-over filter! On close examination, it appears that a rating of, say, 50 W applies only if the speaker is used with a 2nd-order high-pass filter with a cut-off frequency of 4000 Hz. If, however, the cut-off frequency is, say, 2000 Hz, the rating is lowered to 20 W. Without a filter, the rating appears to be only 5 W!

All this is, of course, reasonable, since, at lower frequencies, a diaphragm has to move over a larger distance and tweeters just are not designed for this. Nevertheless, it goes to show that loudspeaker constructors should be well aware of how ratings are specified.

FUSE OR ZENERDIODE?

The question that arises in view of the foregoing is how the tweeters can be protected effectively.

The simplest way is merely to connect a fuse in series with the tweeters. However, this gives only a limited degree of protection, and also introduces a few drawbacks. If a fast fuse is used, chances are that it will blow at the first peak in the music signal. A slow fuse on the other hand does not guarantee that it will always be faster than the tweeters. In other words, the tweeters might still give up the ghost before the fuse blows. Add to this that any fuse introduces a certain resistance, which may vary from some tenths of an ohm to more than an ohm. This should undoubtedly be borne in mind, since, unless compensating measures are taken, it will inevitably lead to some attenuation of the high-frequency sound.

A variation of the standard fuse is a special device with positive temperature coefficient (PTC), which is available from many loudspeaker dealers. It is a semiconductor element that reacts just like a slow fuse when the current through it becomes too high. Unlike a fuse, however, it recovers when the danger is past: it need not be replaced, therefore. Unfortunately, its resistance is slightly higher than that of a fuse.

It is clear that series current limiting by a fuse or PTC device has its drawbacks. What other means are there?

One is a voltage limiter *across* the tweeter. In its simplest form, this could consist of two anti-series connected zener (power) diodes, assuming that the necessary series resistor is already present in the cross-over filter (damping resistor). A possible arrangement is shown in **Figure 1**, in which the zener diodes are at the right. Resistor R_1 is the series (damping) resistor mentioned earlier. If the zener ratings are 5.6 V, the power applied to the tweeter is restricted to about 5 W.

It may be asked whether such a simple protection is sufficiently effective, to which the answer is yes and no. The difficulty is that this sort of protection is too effective. This is because the zener action normally commences at fairly small currents when the zener voltage is nowhere near its nominal value. This results in untimely limiting, which causes a compression effect even at fairly small signals. Another, practical, problem is that power zener diodes are not easy to come by.

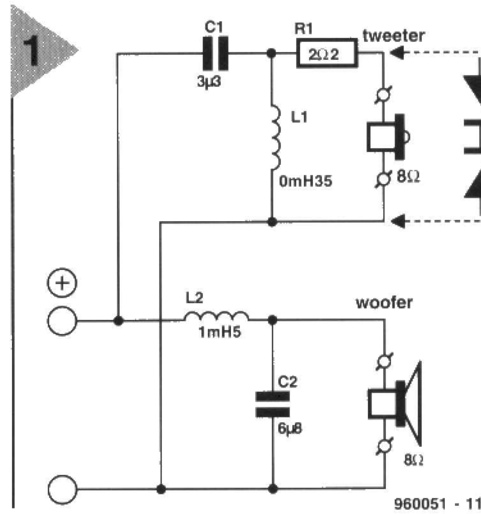


Figure 1. If the cross-over filter contains a damping resistor, R1, for the tweeter, the voltage may be limited by two anti-series-connected zener diodes.

SIMULATED ZENER DIODE

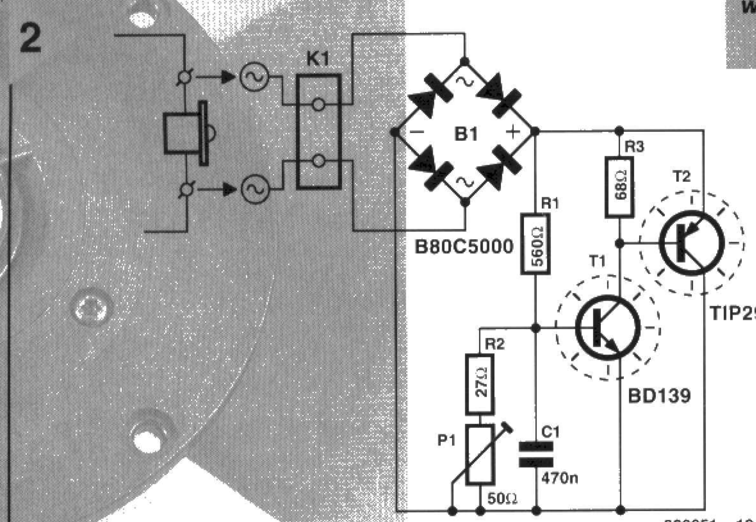
What we need is a protection that is faster and more reliable than a series element and does not have the disadvantages of a pair of zener diodes in parallel. This requirement could be met by a sort of simulated power zener diode that has a sharply defined starting point.

The simple circuit in **Figure 2** is such a zener diode, consisting of two discrete darlington transistors. Connector K_1 is simply connected in parallel with the tweeter terminals. There is no need of a supply voltage, because this is drawn from the loudspeaker signal.

The alternating signal across the loudspeaker is rectified by B_1, so that a pulsating direct voltage exists across network R_1-R_2-P_1, which is averaged (to a degree) by capacitor C_1. When the alternating signal increases, transistor T_1 begins to conduct at a given value determined by the setting of P_1. Transistor T_1 turns on the power transistor, T_2, which consequently short-circuits part of the alternating signal. A part only, of course, because if the signal were short-circuited completely, T_1 would be cut off, leaving T_2 without drive. All this means that there is a limiting effect which stabilizes itself at a certain signal level, just as a zener diode does. The difference is that the simulated zener diode has a defined starting voltage, so that signals below that level are not affected. Thus, compression effects do not occur. In Figure 2, the values of R_1, R_2, and the preset have been chosen to ensure that the zener voltage can be set with P_1 between 5 V and 9 V, roughly corresponding to powers between 3 W and 10 W into 8 Ω.

In the design stages, it was considered to expand the circuit with an indicator LED, but in practice it was found that the music peaks are too short to make an LED light visibly. It is, of course, possible to lengthen the signal peaks electronically, but bear in mind that the required energy must be drawn from the loudspeaker signal and this may lead to an increase in distortion.

Figure 2. The design of a power diode with variable zener voltage is fairly straightforward.



CONSTRUCTION

The limiter is best built on the printed-circuit board shown in **Figure 3**, but it is, of course, just as easily built on a small prototyping board. The only aspect that needs attention is that the two transistors are to be fitted on to a common heat sink of about 6.5 K W^{-1}. This is necessary, because when the twee-ter is overloaded, there is quite a heat dissipation. The transistors must be electrically isolated from the heat sink with the aid of insulating washers

Setting up

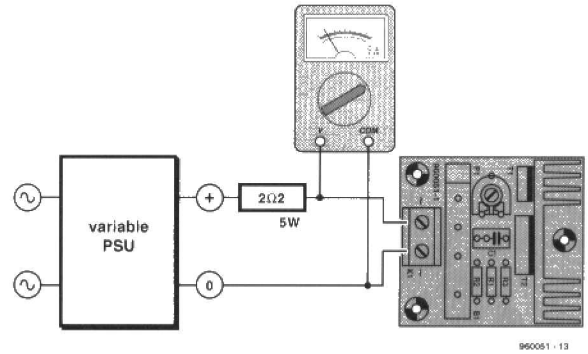
Much thought was given to the control range of P_1. The data books of a number of loudspeaker manufacturers showed that the majority of tweeters are normally rated at 3–5 W, with some as high as 8 W. This led to the decision to make the range 3–10 W into 8 Ω, corresponding to a signal voltage range of 5–9 V. If you have no suitable measuring equipment available, take it as a rule of thumb that the power restriction is about 3 W with P_1 fully anticlockwise, about 5 W with the preset turned one third of its travel clockwise, and about 10 W with it fully clockwise.

Setting the zener voltage of the limiter requires a variable power supply and a multimeter. Connect the power supply across K_1 via a 2.2 Ω, 5 W resistor, and the multimeter in parallel with this as shown in the diagram.

If we assume a power limit, P, of 5 W into a (loudspeaker) impedance, R, of 8 Ω, the signal voltage, u, is:

$$u = \sqrt{PR} = 6.3\ V$$

The power supply provides a direct voltage, which, as far as level is concerned, is equal to $\sqrt{2} = 1.414$ times the r.m.s. value of an alternating voltage. Thus, for the above values of 5 W into 8 Ω, the preset must be set to give a meter reading of $1.414 \times 6.3 = 8.9$ V. Make sure, of course, that the power supply output level is sufficiently high.



and non-metallic screws and nuts. The photograph shows what the finished limiter looks like. A good place for it is on or close to the cross-over filter board. A good alternative is beside the tweeter on the inside of the front panel of the enclosure. Connect K_1 to the tweeter terminals with medium-duty, flexible, insulated circuit wire.

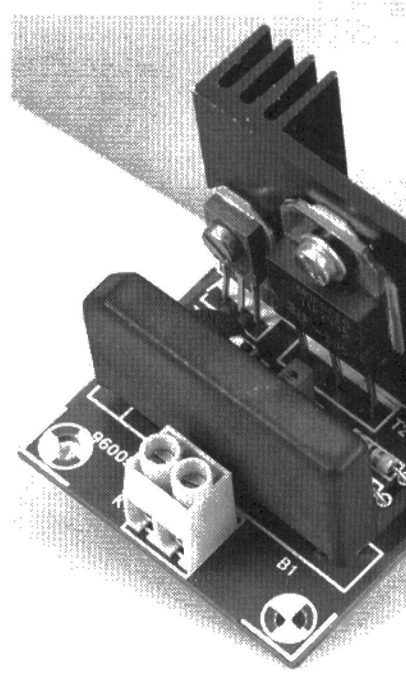
USAGE

As stated earlier, in the design it is assumed that the cross-over filter contains a resistor in series with the tweeter. This resistor is essential, because the surplus voltage when the limiter is active is dropped across it.

If you are worried by the thought that when the limiter is active the amplifier is virtually short-circuited as far as high frequencies are concerned and that it may not be able to cope with this, connect a 500 mA fuse in series with the tweeter. This protects the amplifier against a full short-circuit: its resistance of 0.3 Ω is, in this case, negligible.

The setting of P_1 is described in the box.

[960051]



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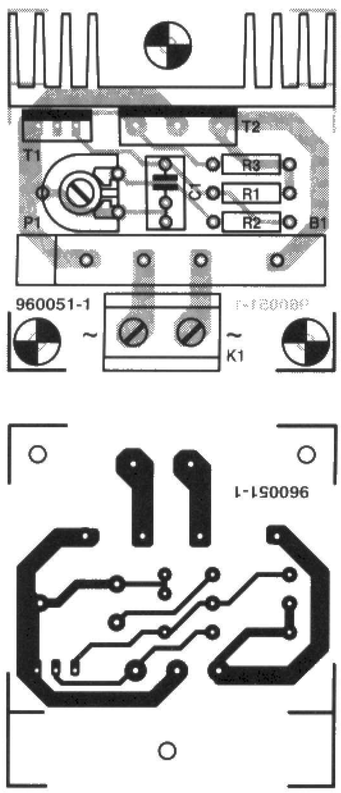


Figure 3. The printed-circuit board for the limiter shows how simple the construction is.

PARTS LIST

Resistors:
R_1 = 560 Ω
R_2 = 27 Ω
R_3 = 68 Ω
P_1 = 50 Ω preset

Capacitor:
C_1 = 470 nF

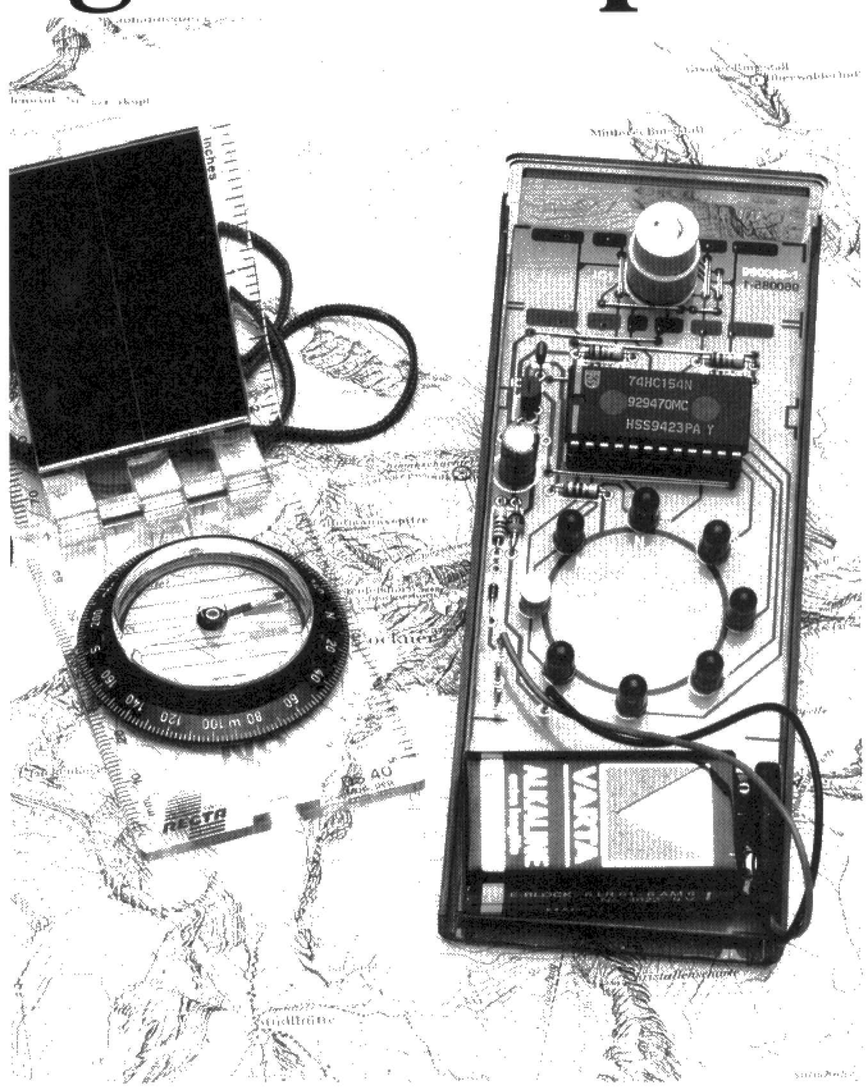
Semiconductors:
T_1 = BD139
T_2 = TIP2955

Miscellaneous:
K_1 = 2-way terminal block for board mounting, pitch 7.5 mm
B_1 = B80C5000
Heat sink, 6.5 K W^{-1}, e.g., Fischer SK59 (37.5 mm) (available from Dau, telephone 01243 553 031)
Insulating washers, and non-metallic screws and nuts for T_1 and T_2

digital compass

In spite of the precision of the GPS (Global Positioning System), the simplest way to determine direction and location is still by a magnetic (mariner's) compass or gyro compass. Nowadays there are also electronic compasses. These compasses have no magnetic needle, but a magnetic sensor that is based on the Hall effect*. Such a sensor needs only a few components to show the directions north (N), north-east (NE), east (E), south-east (SE), south (S), south-west (SW), west (W), north-west (NW) on a compass card.

* See box 'Hall effect'



Design by H. Bonekamp

The Swiss firm Pewatron sells two kinds of compass sensor, both of which react with great sensitivity to the earth's magnetic field. These sensors facilitate the construction of an electronic compass for various applications. However, the analogue type, with its very high resolution, requires a quite complex electronic circuit, whereas the digital type (as used in the present design) only needs a few standard components and a standard logic IC to construct a compass with 45° resolution. The direction is indicated by a number of LEDs built into the compass card. The digital sensor is primarily intended for a hand-held compass, which may also be used in a car, boat or light aircraft.

INCLINATION AND DECLINATION

Not many people know how to handle a compass correctly. It is only when you have learnt to fly, sail a yacht across the sea, or have been on a 'really wild' holiday that you appreciate that the compass needle does not normally point to the north. This has several causes. First, the geographical (true) north and magnetic north are not at the same location. This means that the lines of force surrounding the earth magnet are not parallel to the geographical meridians. Moreover, lines of force do not flow in a constant direction from the south magnetic pole to the north magnetic pole. Their direction fluctuates considerably, and for this reason the magnetic meridian cannot be defined as 'the arc of a great circle joining the north and south magnetic poles'. Instead, it is defined as 'the direction that a compass needle will take up when under the influence of the earth's magnetic field only'. The angle between the magnetic meridian and the true meridian at any place is

1

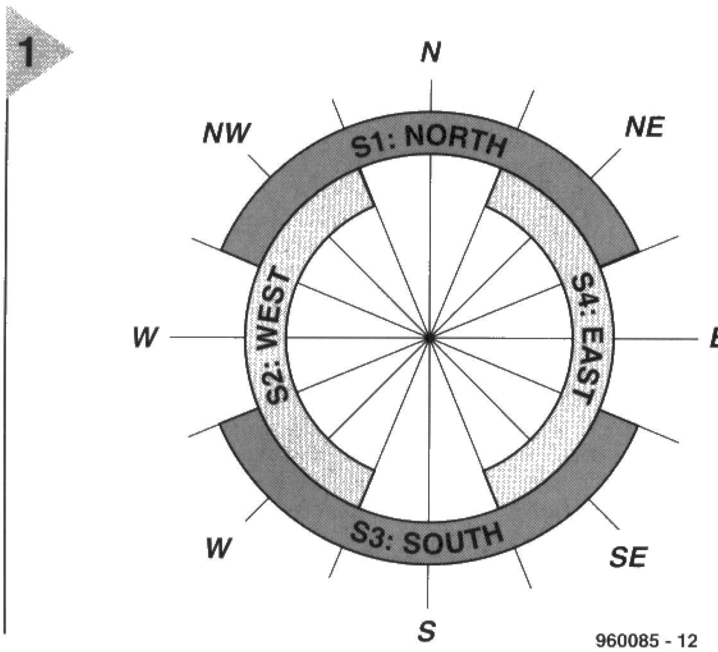


Figure 1. Suitable decoding of the four overlapping output ranges makes resolving the compass card into eight 45° ranges possible.

called the magnetic variation or declination. The north magnetic pole is moving slowly all the time: it makes a circle round the true north pole once in about a thousand years. In Britain, the westerly declination is decreasing by about 10 minutes of arc annually. The foregoing makes it clear that the resulting error in compass reading is greater near the true north pole than at the equator.

Another cause of error is the earth's magnetic field, which is the space around it occupied by its lines of force. Any freely suspended magnetic needle placed in this field will align itself with the lines of force of the field. The direction of this field is horizontal at the magnetic equator, but as you travel northwards, the lines of force begin to dip, until, in Britain, they are inclined at an angle of about 60° to the horizontal. In a modern magnetic compass, the magnetic needle is not allowed to dip. This is achieved by having more than one needle (usually four to eight) so arranged that their common centre of gravity is below the point of suspension of the compass card.

OVERLAPPING RANGES

The Type 6945 digital sensor is a combination of a miniature rotor with sapphire bearings and a Hall effect IC. The rotor is designed for measuring the horizontal component of the magnetic field, but reacts also to the vertical component. It is, therefore, essential that the sensor is held or fitted in such a manner that the rotor moves in the horizontal plane only.

The sensor has four outputs, one for each of the four main compass

2

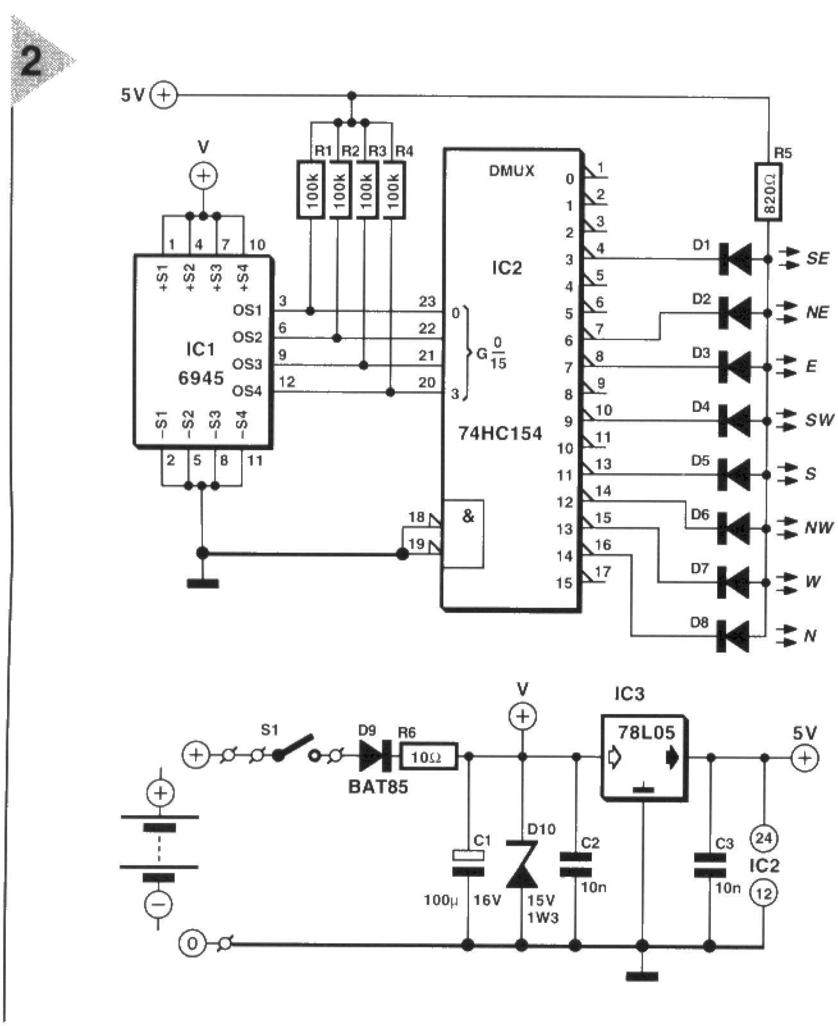
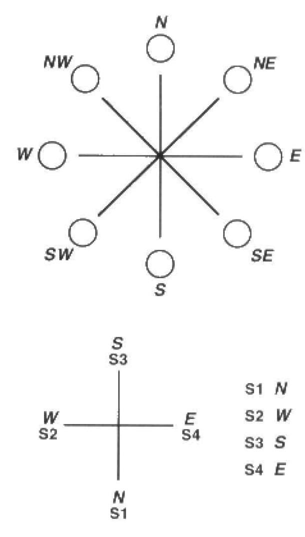


Figure 2. The electronics of the compass is fairly straightforward, but good attention must be paid to the regulation of the power supply lines.



	OS4	OS3	OS2	OS1	DEC
N	1	1	1	0	14
NE	0	1	1	0	6
E	0	1	1	1	7
SE	0	0	1	1	3
S	1	0	1	1	11
SW	1	0	0	1	9
W	1	1	0	1	13
NW	1	1	0	0	12

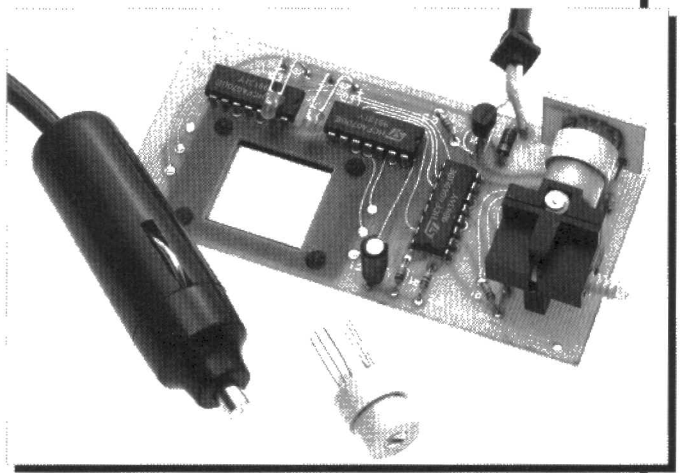
960085 - 11

Construction kit

A full construction kit for the compass with digital sensor is available under type number 6037-G from

Pewatron
Hertistr. 27
CH-8304 Wallisellen
Zurich
Switzerland
Tel. +41 1 8 302 944
Fax +41 1 8 305 157

The kit comprises sensor Type 6945, a PCB with a special liquid-crystal display (LCD) and a number of standard logic ICs. The design uses a number of gates and a 60 Hz oscillator, consisting of two inverters, which drives the backplane of the LCD. Eight XOR gates ensure correct drive of the four segments: N, E, S and W.



points. Each output is low in a range of ±67.5° around the compass point with which it is associated. Thus, adjacent compass points overlap each other by 45° as shown in **Figure 1**. This means that with appropriate decoding, the compass card can be resolved not in four, but in eight (abutting) 45° ranges.

How this is done is shown in **Figure 2**. In this, the evaluation of the four output signals and their conversion into eight ranges is carried out in a somewhat different way from that described in the box on the 6037 kit (using more ICs and an LCD). All that is needed in the present design is a 4-to-16 demultiplexer to drive the LEDs. The Type 74HC154 used in spite of its 16 outputs has the advantage that it does not need additional buffer ICs. The four pull-up resistors are necessary, however, since the sensor has open-collector outputs (n-p-n), which can handle currents of up to 25 mA.

The Type 6945 sensor has a hysteresis that prevents the indication from 'fluttering'. The 6945 is available in two versions: damped and undamped. In the present design the undamped version is used, which reacts immediately to a change of direction. The damped version takes about 3.5 s to follow changes of direction, in which it resembles the pointer of a mariner's compass.

POWER SUPPLY

The power supply for the sensor should be carefully constructed, since the sensor is highly sensitive to all kinds of interference on the supply lines; in fact, it may be irreparably damaged by such interference. (At a price of some £35, that is not acceptable).

The sensor can operate without any difficulty from voltages in the

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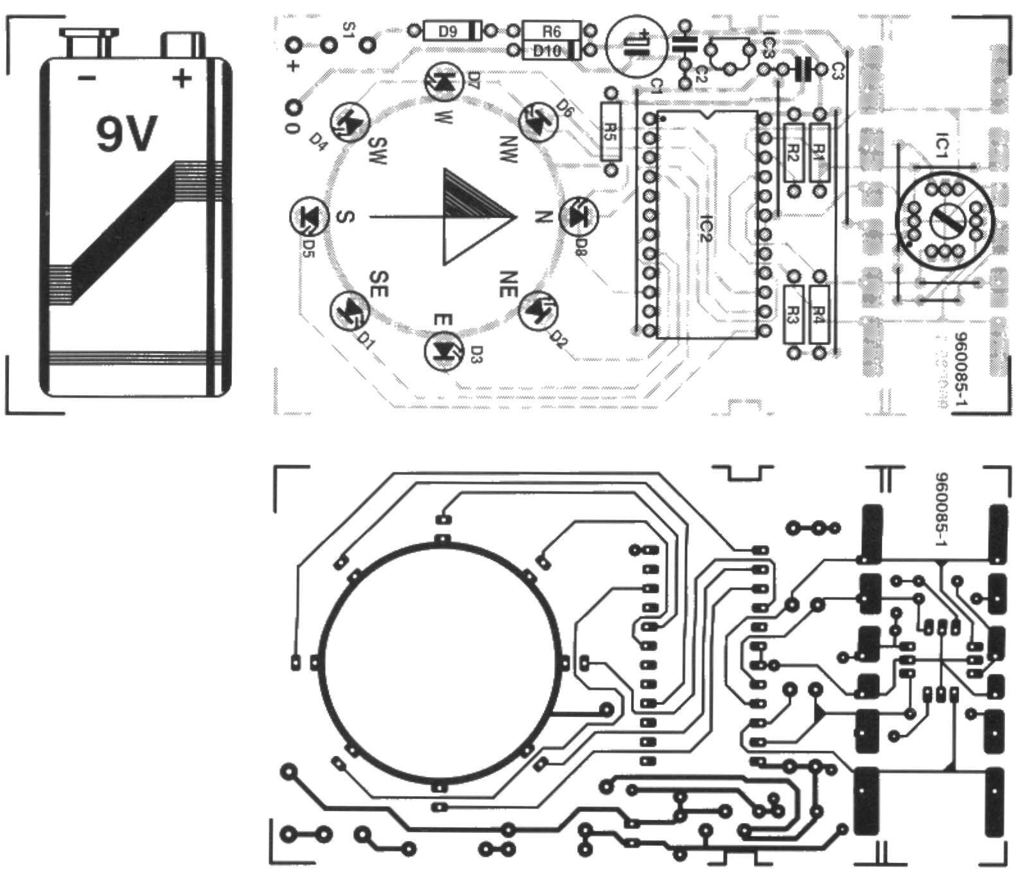
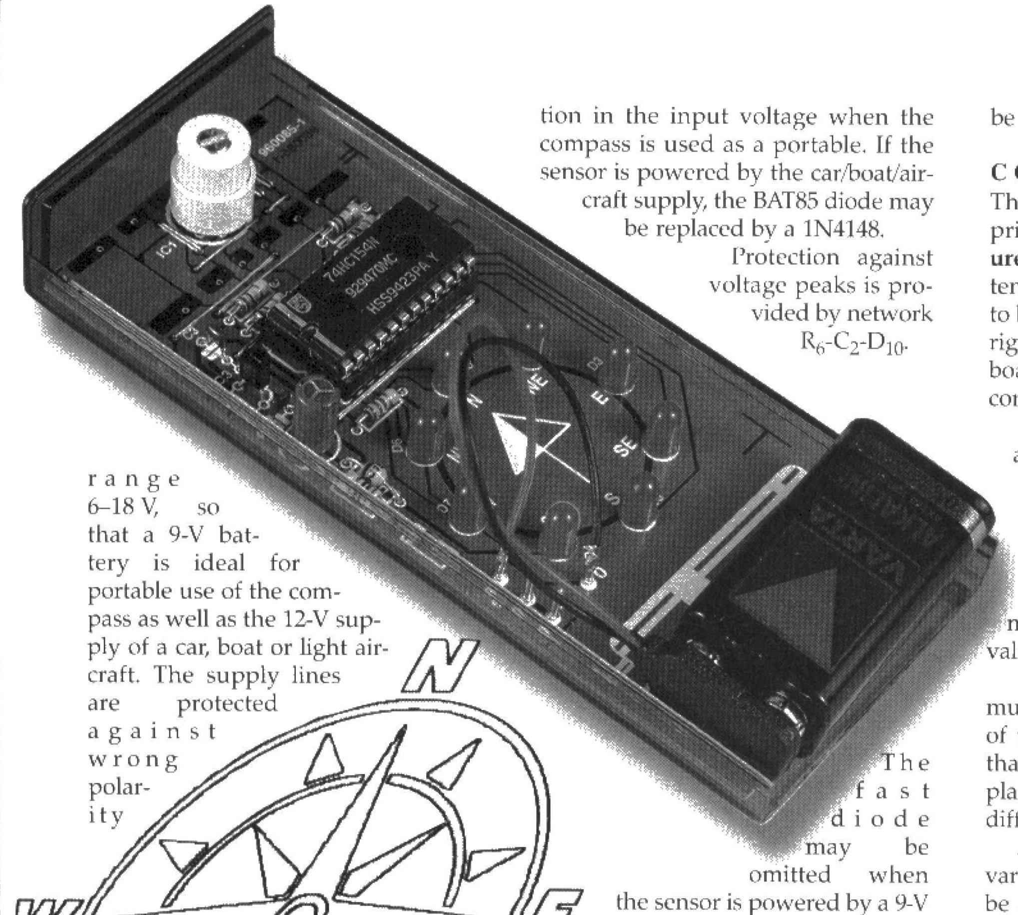
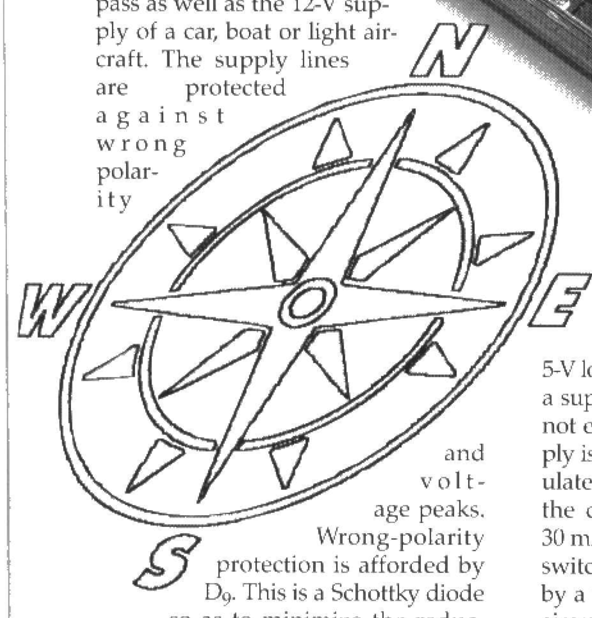


Figure 3. The printed-circuit board for the compass consists of three sections. Make sure to use copper wire (non-magnetic!) for the wire bridges.





range 6–18 V, so that a 9-V battery is ideal for portable use of the compass as well as the 12-V supply of a car, boat or light aircraft. The supply lines are protected against wrong polarity and voltage peaks. Wrong-polarity protection is afforded by D_9. This is a Schottky diode so as to minimize the reduction in the input voltage when the compass is used as a portable. If the sensor is powered by the car/boat/aircraft supply, the BAT85 diode may be replaced by a 1N4148.

Protection against voltage peaks is provided by network R_6-C_2-D_{10}. The fast diode may be omitted when the sensor is powered by a 9-V battery.

Whichever supply is used, the 5-V low-drop voltage regulator provides a supply line of +5 V. This is, however, not enough for the sensor, whose supply is, therefore, taken from the unregulated line before the regulator. Since the circuit draws a current of about 30 mA, it is advisable to fit an on/off switch when the compass is powered by a 9-V battery. In a car, boat or light aircraft, the on/off switch function may be provided by the ignition switch.

CONSTRUCTION

The compass is best built on the printed-circuit board shown in **Figure 3**. The board allows the section intended for the sensor to be cut off and to be fitted in a different location or at right angles to the remainder of the board. This may be very useful if the compass is fitted in a vehicle.

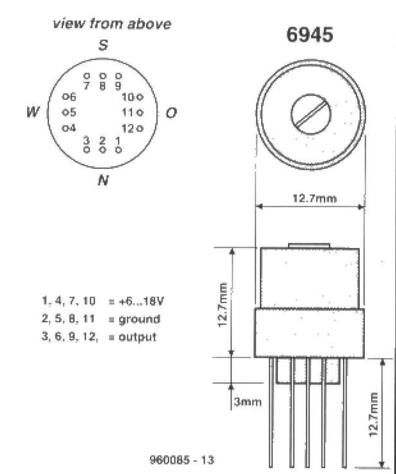
If the distance between the sensor and the remainder of the compass is more than, say, a metre (3 ft), it is advisable to use 5-core screened cable for the connection between the boards. The screen serves as the earth return. In some cases, it may also be neces-sary to reduce the values of R_1–R_4 to not less than 10 kΩ.

Bear in mind that the compass must be fitted in the horizontal plane of the car, boat or aircraft to ensure that the rotor moves in the horizontal plane (which, of course, is sometimes difficult in a boat or aircraft).

Apart from the errors caused by the variation and/or dip, the compass may be affected by another type of error. Like all magnetic compasses, the present one is also affected by external magnetic fields. It is, therefore, essential to ensure that the sensor is not fitted near any magnetic materials.

The prototype is built into a plastic case with transparent lid as shown in the photographs. This type of construction makes it unnecessary for holes for the eight LEDs to be drilled.

[960085]



PARTS LIST

Resistors:
R_1-R_4 = 100 kΩ
R_5 = 820 Ω
R_6 = 10 Ω

Capacitors:
C_1 = 100 µF, 16 V, upright
C_2, C_3 = 10 nF, high stability

Semiconductors:
D_1-D_8 = LED, red, high efficiency
D_9 = BAT85 or 1N4148 - see text
D_{10} = fast zener diode, 15 V, 1.3 W (for instance, Philips BZT03C15; may be omitted - see text)

Integrated circuits:
IC_1 = 6945 (Pewatron - see box 2)
IC_2 = 74HC154
IC_3 = 78L05

Miscellaneous:
S_1 = on/off switch, may be omitted - see text
Enclosure 142×57×25 mm ($5^5/_8$×$2^1/_4$×1 in) - see text

Hall effect

When a current-carrying electrical conductor is placed in a magnetic field, a voltage can develop between one side of the conductor and the other. For this to happen, the magnetic lines of force must be perpendicular, or nearly so, to the line containing the conductor. The voltage then appears at right angles to the magnetic lines of force. If the conductor is a strip of metal or semiconductor, and the magnetic lines of force are perpendicular to the strip, the voltage will appear between opposite edges of the strip. This is known as the Hall effect. The electric-field intensity, E_{HV}, generated by the Hall effect is given by:

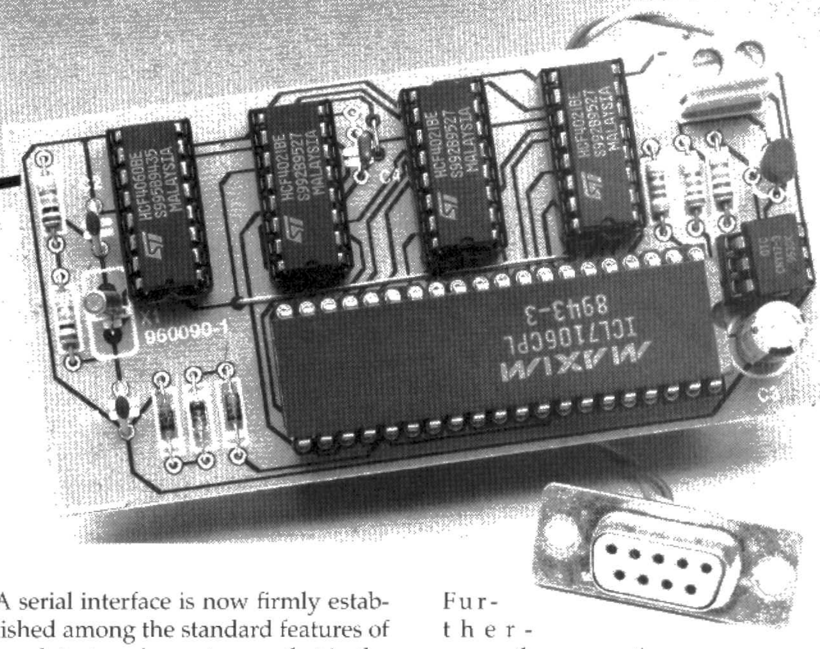
$$E_{HV} = B \cdot I_C \cdot K_H / t,$$

where I_C is the current in the conductor, B is the magnetic-field strength, K_H is a constant, called the Hall constant, and t is the thickness of the material.

The effect is named after its discoverer, the American physicist Edwin Herbert Hall (1855-1938). It is used to investigate the nature of charge carriers in metals and semiconductors, in the Hall probe for the measurement of magnetic fields, and in magnetically operated switches.

RS232 interface for A-D converter ICL7106

Serial-Out for LC displays



Many of today's electronic test instruments feature an RS232 interface for data exchange with a PC. Such an interface brings remote logging, statistic processing and presenting of sampled data within easy reach, all with the aid of a PC. The circuit described here adds an RS232 interface to older test equipment based on the familiar ICL7106 ADC and LCD driver.

Design by Thomas Frey

A serial interface is now firmly established among the standard features of much test equipment, even that in the lower cost range. The terminal programs that come with these instruments allow measurement data to be conveyed to a PC for further processing. Unfortunately, owners of older and home-made test instruments can not reap the benefits of such a PC link, because the required interface is not available. A lot of these instruments typically use the industry-standard ICL7106 from Intersil (now Maxim Inc.). This chip is capable of converting an analogue input voltage into a digital value, and drive a 3.5-digit LCD. The ICL7106 is marked by a relatively small footprint (it is usually mounted underneath the associated LCD), but also by its low price of less than £4.

The complex structure of the converter — it lacks an externally accessible, but non 7-segment-decoded output — requires a small trick if you want to add an RS232 interface to an older test instrument. The circuit discussed here consists of a small adaptor board, which is fitted instead of the ICL7106 in the equipment, and accepts the same chip again as a kind of piggy back add-on. The link to the PC simply consists of two wires (unscreened!) with a length of up to 6m. An external power supply is not required because the circuit is powered from the RS232 interface and the converter's supply. Furthermore, the connection between the test instrument and the PC is electrically isolated, so you do not have grapple with potential differences.

24-BIT PARALLEL TO SERIAL

The operating principle of the circuit in **Figure 1** is quickly explained: the display information, intended for a 3.5-digit 7-segment readout with polarity indicator, is 'tapped' at the converter IC, converted into an RS232 compatible serial datastream (including start and stop bits) with the aid of a shift register, and then fed to your PC's RS232 port via an opto-isolator.

The clock for the ser-

Features

- Simple circuit: few and commonly available parts
- No adjustment required
- Connection option for two adaptors
- Optically isolated
- No supply required
- Source code on disk in TP 6.0

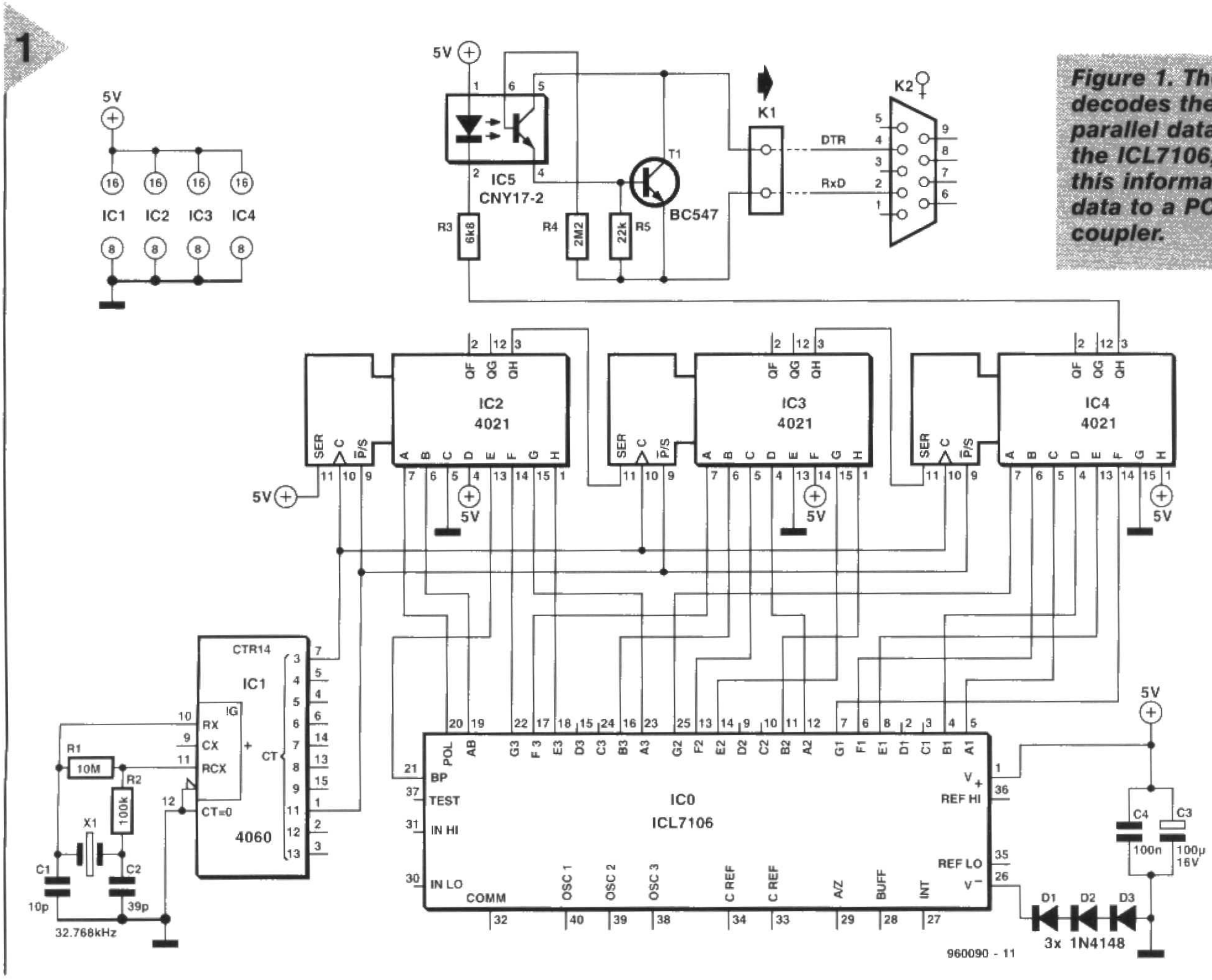


Figure 1. The interface decodes the multiplexed parallel data supplied by the ICL7106, and sends this information as serial data to a PC, via an opto-coupler.

ial data is provided by an oscillator which consists of a quartz crystal (32.768 kHz) and a type 4060 divider. Pin 7 supplies the 2048-Hz shift register clock. Although this frequency does not correspond to a standard baud rate (1200, 2400, etc.), it may be generated by the PC with sufficient accuracy (115,200/56 = 2,057.1 Hz). Odd as the resulting baud rate may be, it does eliminate the need of more divider ICs. An 8-Hz signal which also happens to be available from the 4060 is used to load the shift register.

A 24-bit shift register is built from IC2, IC3 and IC4, which convert the parallel data into serial format. Of each of the three 7-segment readouts (units, tens and hundreds positions), the five segments A, B, E, F and G are sufficient to form the equivalent decimal number. To these are added one bit for the thousands position, one for the polarity and one for the backplane signal. The 18 data bits are split into three bytes, each of which is headed by a start bit (low) and closed off by a stop bit (high). On a high level at pin 9 (P/S), the 24 bits are loaded into the shift register. A subsequent 'low' level causes the bits to be shifted out at the rate of the clock applied to pin 10. Trailing (inactive) stop bits are automatically added to the end of the serial word. At the output of the shift register cascade (pin 3 of IC4) appears a datastream with a length of 3 bytes of 10/2,048 s = 4.9 ms each, at intervals of 125 ms.

The output of the shift registers drives opto-isolator IC5 via resistor R3. At the PC side of the opto-isolator, the signal is amplified by T1. The amplifier allows a relatively small drive current of 1 mA to be used, while it has a positive effect on the current consumption of the opto-transistor. To enable the data to reach the PC, the computer must actuate the DTR line on its RS232 port (i.e., pull the line to +12 V). An active low at the shift register output causes the LED in the opto-isolator to light, and T1 to conduct. Consequently, the RxD line is pulled to +12 V. When T1 is switched off, the internal pull-down resistor of the interface pulls the line to the −12 V level. The relatively low data rates that can be achieved in this way (because the charge contained in the wire and input capacitances can only be reversed slowly), need not be a disadvantage because in most cases only small amounts of data will be involved. The advantages are clear: only two wires, and no external power supply.

Because of the electrical isolation, two supply voltages are required. At the converter side, the circuit uses the supply voltage pin of the ICL7106. This causes a few problems, though, because the 'low' level supplied by the outputs of the ICL7106 is not 0 V, but approximately V_{cc}−5 V. Obviously, that level will not be recognized by the CMOS logic connected to the outputs. The problem is solved by raising the negative supply level of the circuit by about 2 V with the aid of diodes D1, D2 and D3. At a typical supply voltage of 9 V, that creates a ground voltage level of about 2 V, while the threshold voltage of the shift register inputs lies at about 5.5 V. In this way, the shift registers are capable of recognizing a low (approx. 4 V) from a high (9 V).

CONSTRUCTION: YOUR CHOICE

The circuit is best built on the simple printed circuit board shown in Figure 3 (board not available ready-made through the Readers Services). This board may be linked to the main instrument in two ways, as illustrated in **Figure 2.** Either you plug the interface board in or solder it at the component side, *instead* of the ICL7106, or you solder it as an *add-on* at the copper side of the equipment board. The first option (Fig. 2a) is best used if the ICL7106 sits in a socket, and is not covered by the LC display. The serial interface board

is then fitted with a wire-wrap socket whose pins are inserted into the socket from which the ICL7106 has been removed. The IC then migrates to the wire-wrap socket.

The second option (Fig. 2b) leaves the original equipment almost unchanged. This way of mounting the add-on circuit is particularly useful when the ICL7106 is not fitted in a socket, but soldered directly on to the

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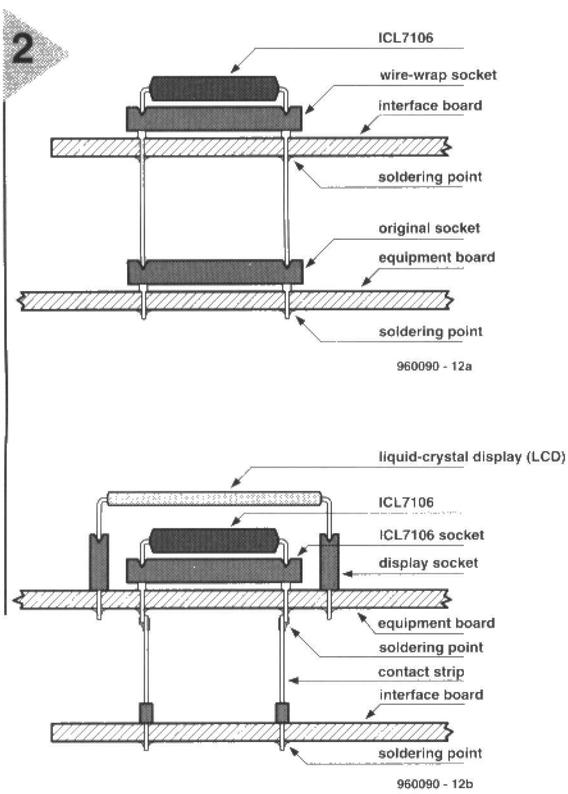


Figure 2. Two mounting options are available for the interface board.

board. Basically, two strips with long pins (Fischer type MK14) are inserted between the two boards. Take care not to overheat the ICL7106 while soldering its pins. Also note the limited distance of just 15 mm between the boards, this requires the use of low-profile components, while C3 should be mounted flat on the board. Whichever mounting method you choose, proper and accurate soldering is a must for reliable, solid joints. Obviously, you have to decide on the mounting method before you start populating the board, whose layout is given in **Figure 3.**

SOFTWARE

A small Turbo pascal program called **meas7106** allows a PC to collect, display and report measured data. To call up the program, simply type

meas7106 [/1/2] [/lfilename]

where the option */1* or */2* selects the serial port on your PC (COM1: or COM2:, the latter is the default). The other option, */l* and *filename*, allows a log file to be created which contains the measured data (eight values per second) in ASCII format. From there, any extension is, in principle, possible, for instance, a graphics display running under Windows. Apart from the executable program **meas7106.exe**, the disk supplied through our Readers Services also contains the source code written in Turbo Pascal 6.0 (**meas7106.pas**). A small modification to the program is sufficient to enable a second circuit to be linked to the same interface. The hardware clue for this is to use the RTS line (pin 7 on the sub-D socket) as a second supply. When DTR is active and RTS inactive, data may be read from converter 1. Conversely, with DTR switched off and RTS actuated, the other converter is selected.

(960090)

COMPONENTS LIST

Resistors:
R1 = 10MΩ
R2 = 100kΩ
R3 = 6kΩ8
R4 = 2MΩ2
R5 = 22kΩ

Capacitors:
C1 = 10pF
C2 = 3pF9
C3 = 100µF 16V radial
C4 = 100nF

Semiconductors:
D1;D2;D3 = 1N4148
T1 = BC547
IC1 = 4060
IC2;IC3;IC4 = 4021
IC5 = CNY17-2

Miscellaneous:
X1 = 32.768KHz quartz crystal.
K1 = 9-pin sub-D socket.
One 40-pin wire-wrap socket or two 20-pin socket strips (Fischer MK14, Dau Components).
Software on disk, order code 966016-1 (see Readers Services page).
Printed circuit board not available ready-made.

3

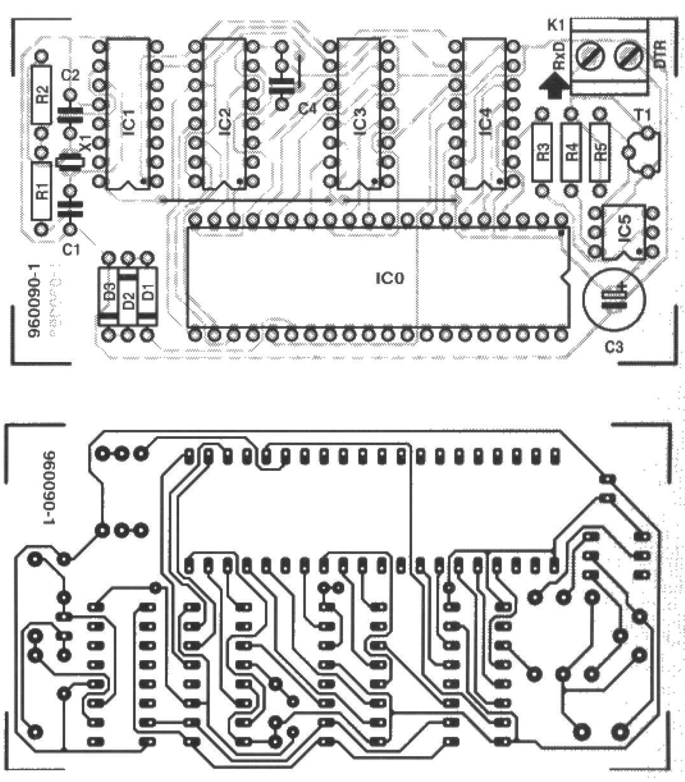
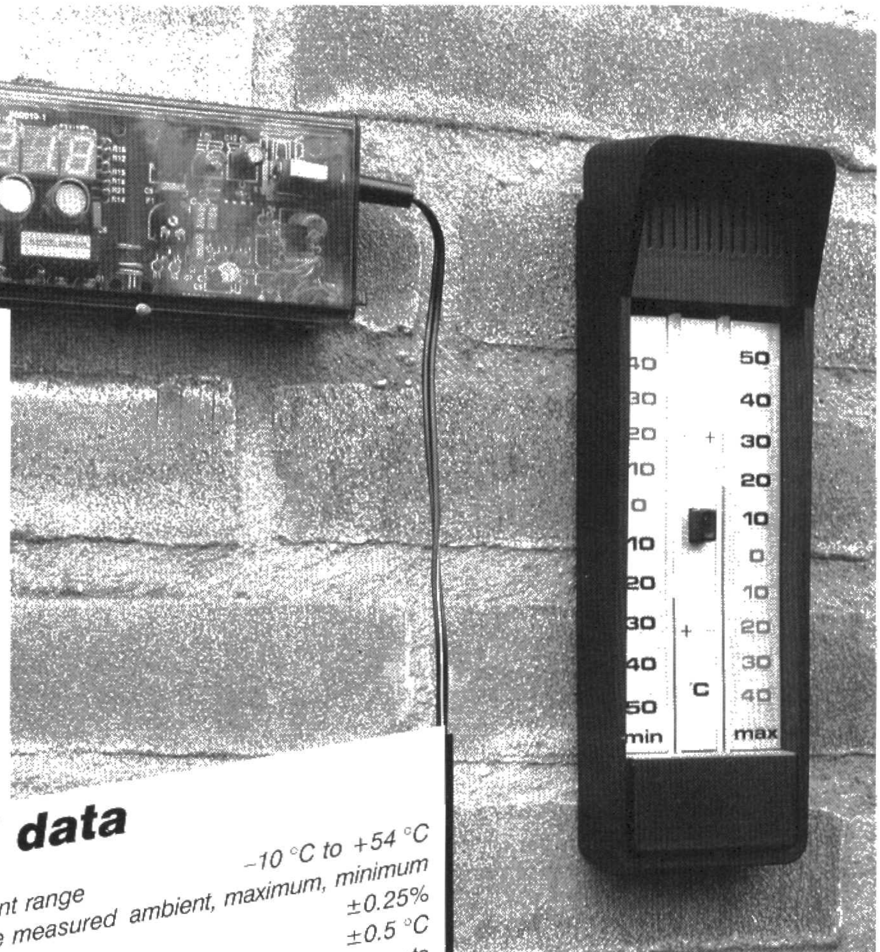


Figure 3. Track layout and component mounting plan of the single-sided circuit board for the interface.

digital maximum and minimum thermometer

Temperature, which is not a tangible quantity – it is a relative ratio – is important for all life on earth. It is, particularly in western Europe, an introductory topic of conversation with comparative strangers on the bus, or in a shop ("Cold last night, wasn't it?" and "Warm today, don't ye think?") Without such introductions, everyday life would be rather quiet. The recording of the lowest and highest temperatures during , say, a 24-hour period, became possible by the maximum and minimum thermometer developed by the British physicist Six. The present article describes a digital version of this well-known instrument.

Based on an idea of A. Trags



Brief data

Measurement range	–10 °C to +54 °C
Temperature measured	ambient, maximum, minimum
Non-linearity	±0.25%
Measurement error	±0.5 °C
Averaging	over 16 measurements
Overflow indication	flashing display
Power supply	9–15 V=
Current drain	about 100 mA

The obsession of many people in western Europe with the weather is baffling (in most of the rest of the world, even in other moderate climate zones, weather is not a frequent or popular topic of conversation). Of course, people in the southern USA or the Far East will discuss the progress of the current hurricane or typhoon, but that is all.

Be that as it may, many readers will be interested in the digital maximum and minimum thermometer discussed in this article. It is based on an ST62T10-HDW microprocessor from SGS Thomson and an LM35 sensor/interface. The measurements are shown on three 7-segment displays.

The ST62T10 is housed in a DIL20 case and has 64 bytes RAM, 1828 bytes ROM, twelve I/O lines, a timer, a watchdog timer, and an 8-bit analogue-to-digital converter (ADC) with eight analogue inputs. All necessary software for the thermometer function is stored in the ROM. The variables used by the software are located in the RAM.

COMPACT DESIGN

Thanks to the small microprocessor, the design is very compact, which is, of course, a prime requirement for a thermometer.

The processor quantizes the signals generated by temperature sensor IC_3, computes these, stores the measurements, and provides the drive for the

The LM35 sensor

The LM35 from National Semiconductor is a three-terminal intelligent temperature sensor that generates an output voltage which is directly proportional to the ambient temperature. The scale factor is 10.0 mV °C^{-1}.

Thanks to the calibration carried out with a laser during the production stages, the sensor is very accurate and yet not expensive. External adjustments are not needed.

Because of the low current drain, averaging ≤ 60 µA, self-heating is low. According to the manufacturer's data sheet, the maximum error caused by self-heating is, in still air, 0.08 °C, which is negligible.

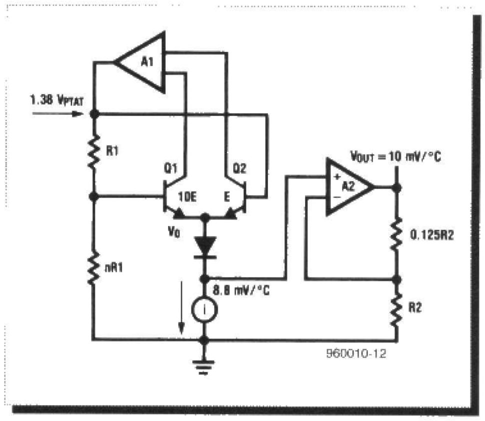
The supply voltage for the sensor may lie between 4 V and 30 V.

The diagram shows that the sensor consists of a circuit which stabilizes the potential to a fixed value and a current source across which the voltages varies with temperature at 8.88 mV °C^{-1}. This voltage is amplified ×1.25 to give a final scaling factor of 10 mV °C^{-1}.

The op amp provides an output impedance of only 0.1 Ω.

The maximum output current is 1 mA.

The chip is available in a number of versions, among which one with a metal case, the LM34, which provides an output voltage of 10 mV °F^{-1}.



multiplexed display.

The clock signal is generated by an on-board oscillator and an external 8-MHz crystal, X_1.

The reset network consists of R_9, C_8 and push-button switch S_1. This network generates the necessary reset pulse for the processor to start after the supply has been switched on. Resetting during operation is possible by pressing switch S_1.

Seven outputs of I/O port *B* are used to drive discrete segments of the display. The displays are multiplexed by I/O outputs PA_1–PA_3. When the (logic) level at the selected output goes low, the associated transistor (T_1–T_3) comes on, which results in voltage being supplied to the relevant display segment.

When PA_0, the fourth input of port *A*, is made low by the closing of switch S_2, first the maximum temperature and then the minimum temperature are shown on the display.

The decimal point on the centre display segment, LD_2, is actuated continuously via resistor R_{21}.

The I/O pin PB_7 is arranged as an analogue input and ensures that the analogue output signal of the sensor/interface has access to the on-board ADC.

Diodes D_1 and D_2 protect the inputs against high voltage levels.

Potential divider R_1-R_2-P_1 provides a reference voltage which can be preset between 600 mV and 870 mV. This voltage is buffered by IC_{2a} and then applied to the negative terminal of temperature sensor IC_3 via R_4. The sensor has a measurement range extending from –55 °C to +150 °C, only a portion of which is utilized in the present design. Its output voltage varies by 10 mV °C^{-1}, which, in the

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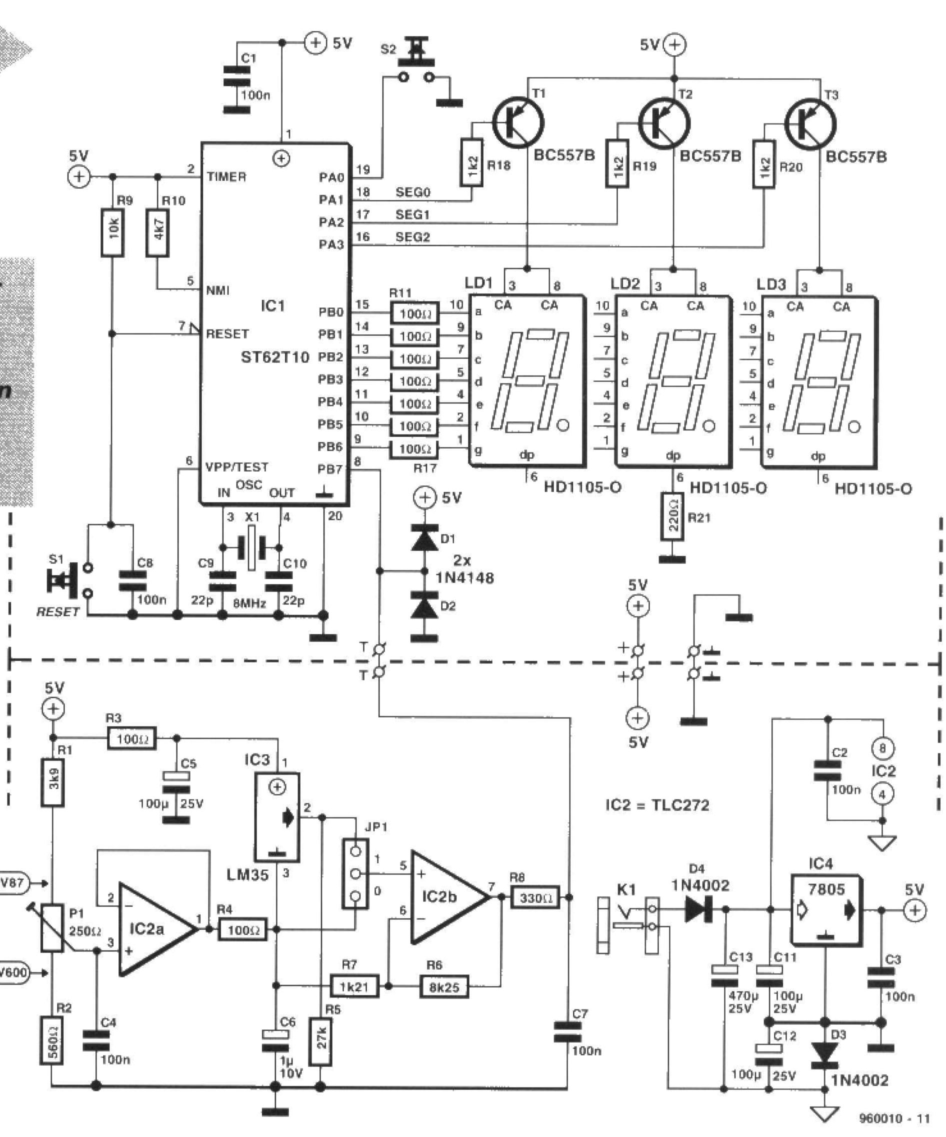

Figure 1. Circuit diagram of the digital maximum and minimum thermometer, which is based on an SGS Thomson Type ST62T10 microprocessor

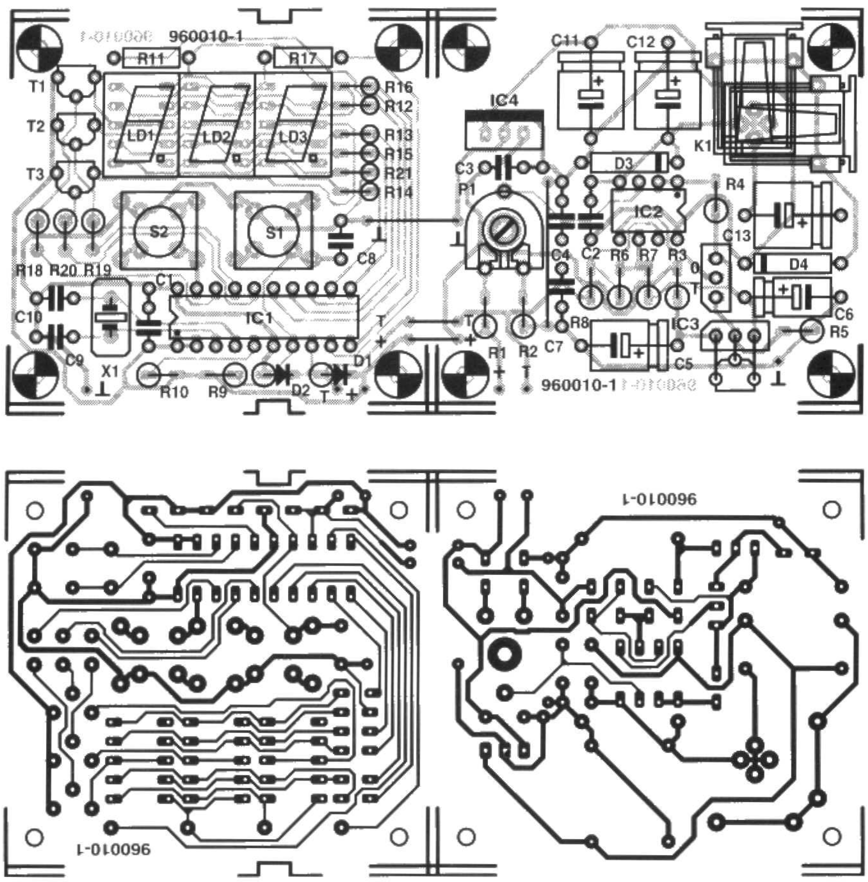

Figure 2. Printed-circuit board for the thermometer; this may be used as shown or, for a more compact unit, be cut into two.

present circuit, means from −100 mV to +540 mV. The negative sign of the −100 mV level merely means that the potential at pin 2 of IC_3 is 100 mV lower than that at pin 3. Since the potential at pin 3 is normally 780 mV, pin 2 is always positive with respect to earth.

Since the ADC in IC_1 can handle voltages between 0 V and 5 V only, the output potential of IC_3 must be raised, which is achieved by applying the reference voltage at pin 2 of IC_{2a} to the negative terminal of the sensor.

Operation is optimal when the auxiliary voltage set with P_1 is 780 mV. The reference voltage used here requires that, in accordance with the data sheet, the sensor should have a 27 kΩ resistor, R_5 to earth.

Jumper JP_1 enables selection of one of two input signals to the non-inverting input, pin 1, of amplifier IC_{2b}. In position 0, the auxiliary voltage is applied to pin 1; in position 1, the output voltage of the sensor. It is of interest only during calibration; in normal operation, it is always set to position 1.

The operating point of non-inverting amplifier IC_{2b} is chosen so that the desired measurement causes a voltage range of 0–5 V at the input of the ADC. The reference potential for this converter is 5 V, while the output of the sensor varies, as already stated, from 100 mV to 540 mV. The requisite voltage amplification, determined by R_6 and R_7, must thus be 5/0.64 = ×7.81. With these values, the ADC has a resolution of four steps per °C (256/64), which results in a display resolution of 0.25 °C. The displayed result is always computed from 16 measurements, which ensures that small(ish) measurement errors, which are always possible, are eliminated.

The auxiliary voltage of 600 mV is needed to enable the operational amplifiers being able to drive signals down to earth potential.

The power supply is traditional. The input voltage should be 9–15 V. Diode D_4 provides half-wave rectification of the alternating input voltage and protects the supply against incorrect polarity of the mains adaptor. Capacitor C_3 buffers the supply lines.

Diode D_3 in series with the earth terminal of voltage regulator IC_4 raises the earth potential by about 0.6 V. This arrangement gives the op amps, as stated earlier, a small negative supply voltage.

PARTS LIST

Resistors:
- R_1 = 3.9 kΩ
- R_2 = 560 Ω
- R_3, R_4, R_{11}–R_{17} = 100 Ω
- R_5 = 27 kΩ
- R_6 = 8.25 kΩ
- R_7 = 1.21 kΩ
- R_8 = 330 Ω
- R_9 = 10 kΩ
- R_{10} = 4.7 kΩ
- R_{18}–R_{20} = 1.2 kΩ
- R_{21} = 220 Ω
- P_1 = 250 Ω preset

Capacitors:
- C_1–C_4, C_7 = 100 nF
- C_5, C_{11}, C_{12} = 100 μF, 25 V
- C_6 = 1 μF, 10 V
- C_9, C_{10} = 22 pF
- C_{13} = 470 μF, 25 V
- C_8 = 100 nF, pitch 5 mm

Semiconductors:
- D_1, D_2 = 1N4148
- D_3, D_4 = 1N4002
- T_1–T_3 = BC557

Integrated circuits:
- IC_1 = programmed ST62T10 (Order no. 956515-1 – see Readers Services)
- IC_2 = TLC272
- IC_3 = LM35
- IC_4 = 7805

Miscellaneous:
- K_1 = jack for accepting mains adaptor plug (board mounting)
- S_1, S_2 = push-button switch with single make contact
- X_1 = crystal, 8 MHz, low model
- LD_1–LD_3 = HD1105-o (orange)
- Enclosure to individual requirements
- PCB + programmed processor Order no. 960010-1 (if the board is not needed, the programmed processor is available under Order No. 956515-1)

Capacitors C_3, C_{11} and C_{12} decouple the regulator.

Since the circuit draws a current of just about 100 mA, the regulator does not need a heat sink.

CONSTRUCTION

The thermometer circuit is best built on the printed-circuit board shown in **Figure 2**. The board may be used in two different ways. As shown, it fits upon completion directly in the enclosure shown in the photograph. If a smaller enclosure is preferred, the board may be cut into two as indicated. This gives a board for the analogue section, and one for the digital section of the circuit.

The marked slots at the edges of the digital board should be filed out to give a neat entry for the cables connecting the board to the sensor.

The two boards may be sandwiched, track sides opposing, with the

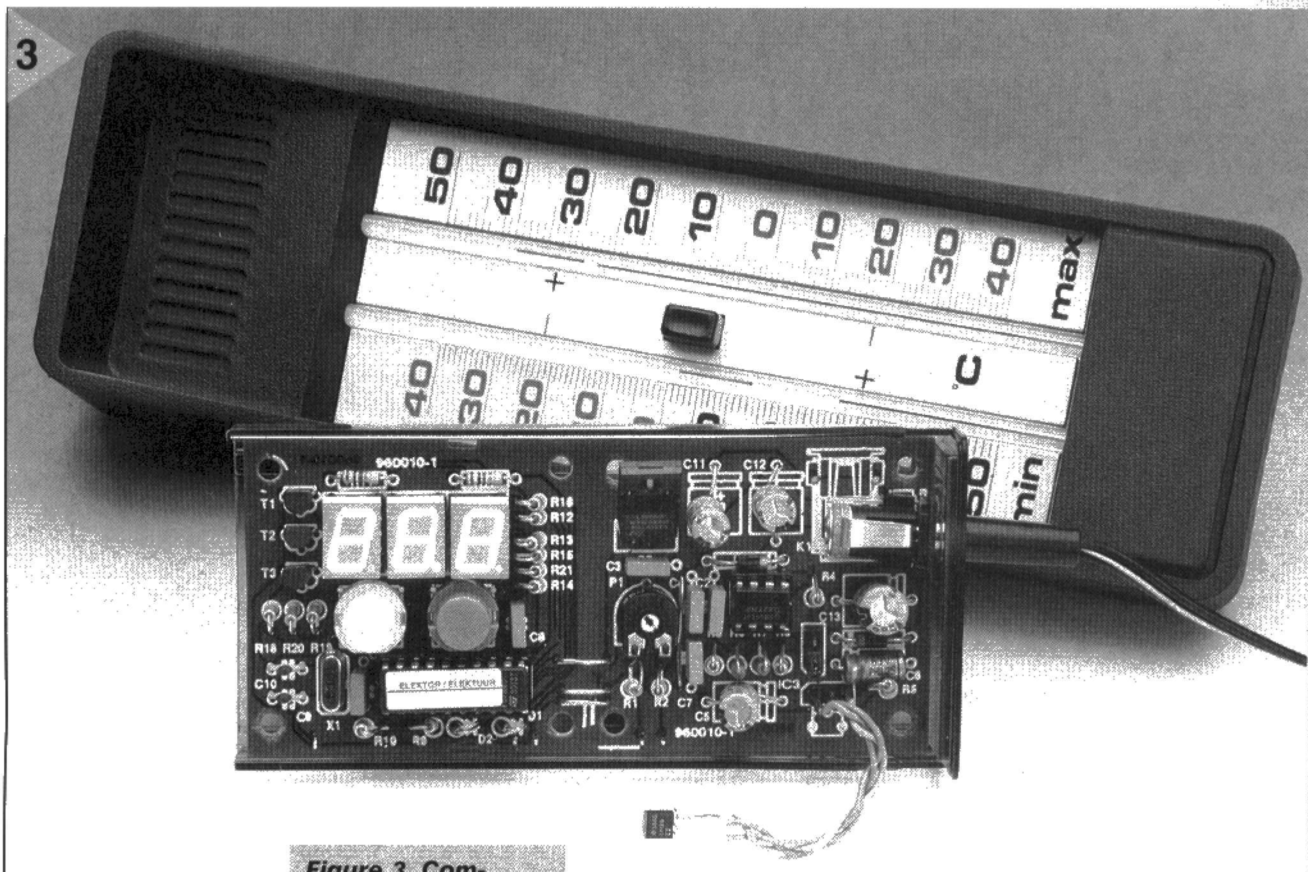

Figure 3. Completed prototype of the digital maximum and minimum thermometer.

aid of four insulated spacers. They are electrically interconnected by three wire bridges between +, ⊥, and T.

Completion of the digital board should not present any undue difficulties. Most resistors should be bent so that they may be mounted vertically. Sockets may be used for the three displays and IC_1.

The sensor should be linked to the analogue board (three-way terminal near R_5) via three lengths of flexible, insulated circuit wire. If the sensor were fitted on the board, heating of the board would give rise to measurement errors.

CALIBRATION

All that is needed for calibrating the thermometer is a dish with melting ice, which provides the temperature reference of 0 °C. At that temperature, the sensor provides an output voltage of 0 V. Set the jumper to position 0, whereupon the offset voltage generated by IC_{2a} is applied to the non-inverting input, pin 5, of IC_{2b}. Adjust P_1 until the display reads 00.0. Note that the relevant position of P_1 is not precisely defined: set it at the centre of the range found.

Set the jumper to position 1 and place the sensor in the dish with melting ice. After a minute or so, the display should again read 00.0. This completes the calibration.

USING THE THERMOMETER

When the supply voltage is switched on, or the reset knob pressed,the thermometer shows the ambient temperature. After a reset, the maximum and minimum temperature readings show the same value as the ambient temperature. If the ambient temperature is lower than –9.7 °C, the display flashes –9.7; if it is higher than 53.7 °C, the display flashes 53.7.

When switch S_2 is pressed, first the maximum temperature (HI) and then the minimum temperature (LO) are displayed.

FINALLY...

When the thermometer functions correctly, it should be fitted in a suitable enclosure as discussed under 'Construction'. The choice of enclosure depends to a large extent on whether the thermometer is to be used indoors or outside.

[960010]

rechargeable-battery systems

The market for microelectronic equipment is growing at a seemingly ever-increasing rate. After the era of discrete semiconductors, it is now integrated circuits that make possible the production of small and smaller portable electronic equipment. It is estimated that in Britain every family has at least one portable radio and one in every three people has a mobile telephone. Many cars have remote car locks, not to speak of the remote control units for the video recorder, the audio system, and so on. All these units need batteries, which also have to become smaller and smaller (have a look inside your quartz crystal watch: and that battery is not small by current standards).

By our Editorial Staff

(foto: VARTA)

It may come as a surprise to some readers that most portable electronic equipment is powered by dry batteries: the world market for these is gigantic. In this overview, however, we will look at rechargeable batteries only. Although these come in many shapes and sizes, there are relatively few basic technologies on which they are based. During and after the Second World War, the daddy of them all, the lead-acid battery, was followed in quick succession by a host of different systems based on different materials: silver, nickel, zinc, and lithium. These metals are used in combination with various other materials: nickel-iron; nickel-zinc; silver-hydrogen; silver oxide-zinc; zinc-air; cadmium-air; aluminium-air; lithium-iodine (almost universally used in cardiac pacemakers); lithium-molybdenum; lithium-iron-aluminium; and so on. This article will look at a few of these.

LEAD-ACID BATTERIES

The lead-acid battery is still the most widely used secondary battery in the world, mainly because of its application in the automotive field, although it has a growing number of other applications. Its advantages are low cost, high voltage per cell and good capacity life. Its disadvantages are its weight and poor low-temperature characteristics.

An open-type lead-acid battery consists of a number of lead plates suspended in sulphuric acid contained in a tough, plastic, spill-proof case. For many years now, sealed lead-acid batteries have also been available. Although these are not produced in the same quantities as the non-sealed type, their uses are increasing.

NICKEL-CADMIUM BATTERIES

Nickel-cadmium (NiCd) batteries have a nickel anode and a cadmium cathode immersed in potassium hydroxide (KOH), normally contained in a tough, sealed plastic container (only low-capacity types – over 30 Ah, they are normally of the open type which requires periodic topping up to re-

place electrolyte).

Nickel-cadmium batteries have a long life (typically 1000 hours at the I_{10} rate), and good low-temperature characteristics. Their cost is, however, relatively high.

Sealed NiCd batteries are normally rated at the C, C_n, or xC_n rate. These are, respectively, the discharge current in A, numerically equal to the rated battery capacity in Ah, which discharges the battery in 1 hour or n hours. The x indicates a discharge current of x times the rated battery capacity in Ah.

When a NiCd battery gets warm, its capacity, compared with other types of battery, drops. This is the reason that a NiCd battery is normally charged at a low rate. However, many appliances, such as mobile telephones, using NiCd batteries, come as standard with a fast charger.

Another problem with NiCd batteries is their lack of charge retention, which is why it is recommended that these batteries are always fully discharged before they are recharged.

The most serious aspect of NiCd batteries is, however, an environmental one. When such a battery is at the end of its life and discarded, the risk of the dangerous cadmium in it ending up at a rubbish tip is great. This is the reason that environmentalists (which should be all of us) advocate their total discontinuance.

NICKEL-METAL-HYDRIDE BATTERIES

Nickel-metal-hydride (NiMH) batteries are a development of the NiCd battery, and have been widely used in space batteries for a number of years. Their structure is similar to that of NiCd batteries, but the cadmium cathode has been replaced by a metal alloy. During normal operation of a sealed NiMH battery, hydrogen atoms collect at the cathode and produce metal hydride. The hydrogen is consumed again during discharge, leaving the metal unaltered.

NiMH batteries do not suffer from the lack of retention so typical of NiCd batteries. Also, they have a higher energy-to-volume ration than NiCd batteries.

In contrast to the decreasing capacity of NiCd batteries with rising temperature, the capacity of NiMH batteries increases with rising temperature.

A drawback of NiMH batteries is their relatively high self-discharge, which starts levelling out only at temperatures below –10 °C.

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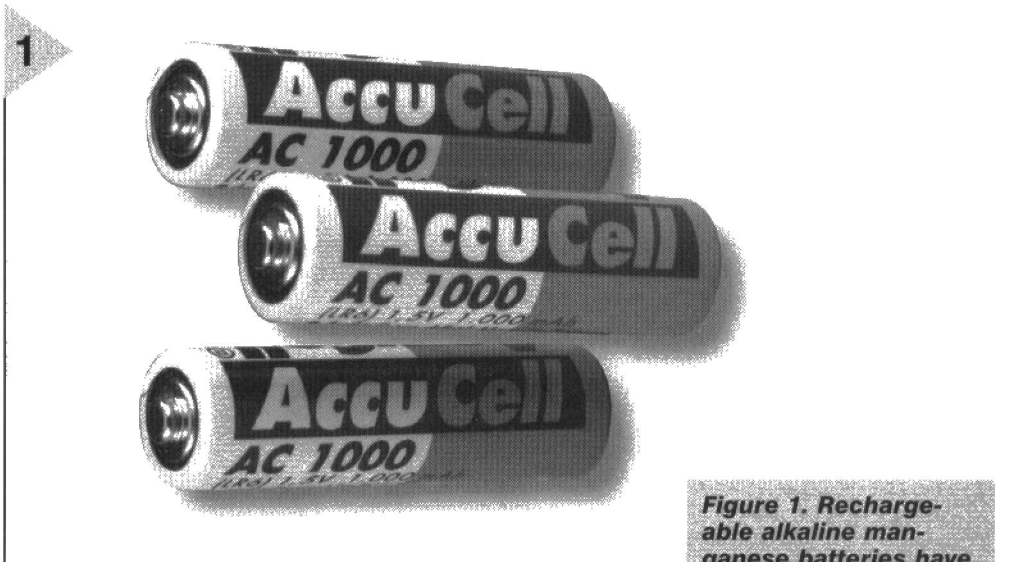


Figure 1. Rechargeable alkaline manganese batteries have been available from Union Carbide (Eveready) and Battery Technologies Inc. have been available since the late 1980s. For some reason, they have not (yet) caught on Europe.

LITHIUM-ION BATTERIES

There are many types of lithium battery; some of the more recent ones are lithium-molybdenum (LiMo) and lithium-ion (Li-ion) batteries. In view of their very small self-discharge and large capacity per unit volume, Li-ion batteries appear to have a bright future. Lithium-based secondary batteries, although developed in the early 1970s, have been entering mainstream electronic designs only since the late 1980s, particularly in consumer, portable equipment and non-volatile memory backup applications, where small size, long life and low cost are prime requirements.

The practicality of lithium is

2

Figure 2. Nickel-cadmium batteries may replace primary carbon-zinc and alkaline manganese in most portable equipment.

greatly enhanced by the progress in CMOS technology. As low-power CMOS technology advances further, gaining a larger share of the integrated circuit market, lithium batteries will no doubt prove of great value.

The anode of an Li-ion battery consists of a lithium alloy, and the cathode of carbon or a metal alloy. These are immersed in an organic liquid containing a saline solution. Lithium ions move between the electrodes when the battery is being charged or discharged.

Since the materials used in lithium batteries have a smaller mass per unit energy produced than is the case, for instance, in a NiCd battery, lithium batteries are much lighter.

The capacity-to-volume ratio of Li-ion batteries is about twice that of NiMH batteries.

Li-ion batteries have a life of more than 1200 cycles.

RECHARGEABLE ALKALINE MANGANESE BATTERIES

Alkaline manganese batteries were until recently typical of non-rechargeable batteries. However, in the late 1980s rechargeable (secondary) versions of this type of battery have become available in the USA (Union Carbide; Battery Technologies) – somehow, they have not (yet) caught on in Europe.

These batteries use a specific electrochemical process, are maintenance-free and hermetically sealed. They were designed as an alternative to NiCd batteries for electronic applications where low initial cost and low operating costs are imperative. The alkaline manganese secondary battery cannot be recharged as many times as the NiCd battery, but its initial cost is very small compared to that of an equivalent NiCd battery.

The energy per cell decreases with each charge/discharge cycle, although the open-circuit voltage remains substantially the same. Manufacturers' data suggest that alkaline manganese secondary batteries can be recycled 50–750 times.

The degree of loss per cycle is partly determined by the moment at which recharging is commenced. The earlier in the discharging process this is, the larger the residual capacity. Also important in this respect is a not too heavy load on the battery: discharge currents between 100 mA and 150 mA are recommended.

Secondary alkaline manganese batteries are about twice as expensive as primary alkaline manganese batteries. However, in view of the fact that during their lifespan they deliver 20–50 times as much energy, the investment is worth while.

Secondary alkaline manganese batteries can be recharged only by specific charging equipment.

THE FUTURE

The evolution of new battery systems is inexorable. As far as can be seen at present, two systems are likely to dominate in the next 5–10 years: zinc-air secondary batteries and lithium-polymer secondary batteries.

The zinc-air primary battery has been in use for some time in the form of button types for the supply of, for instance, hearing aids.

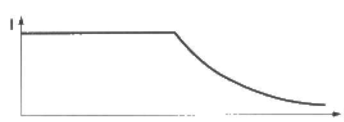
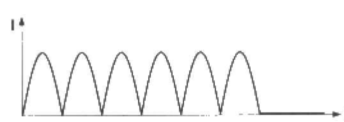
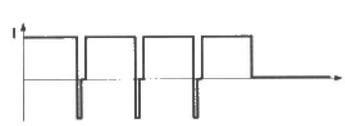
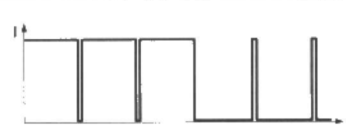
Early models of the zinc-air secondary battery have shown an energy density of some 170 W h kg^{-1} at the C_5 rate of discharge. This is about twice as high as that of current rechargeable batteries. Unfortunately, they are limited to about 50 charge/discharge cycles owing to problems with separator materials and the platinum on the anode. However, these will, no doubt, be overcome within the very near future.

The lithium-polymer battery also has an energy density well in excess of that of, for instance, an NiMH battery. Here also, designers are faced with problems, primarily the low number of charge/discharge cycles. These appear to be caused by degradation of the active components in the cell, probably owing to the reaction between lithium and the electrolyte, producing ethylene, propy-

Table 1. Properties of some important types of rechargeable battery, all R6 size. For comparison's sake, the table includes data of a primary alkaline manganese battery. R6 is the IEC reference, in which the letter R indicates that the battery is cylindrical; the number 6 signifies a particular size.

Type of battery	primary alkaline	secondary alkaline	lead acid	NiCd	NiMH	Li-ion accu
Capacity	2.5 Ah	1 Ah	-	0.7 Ah	1 Ah	0.7 Ah
Energy density	3.5 Wh	1.5 Wh	-	0.8 Wh	1.2 Wh	2.6 Wh
E.M.F.	1.5 V	1.5 V	2.0 V	1.2 V	1.2 V	3.6 V
No of cycles	1	50	500	1000	1000	1000
Self-discharge†	1%	0,4%	6%	15%	25%	0.1%
Peak current	limited	limited	good	good	limited	moderate
* per cell	† per month					

Table 2. Characteristics of charging currents that may be used for charging secondary batteries: they all have advantages and drawbacks.

Method	Remarks	
Limiting of current and voltage	lead-acid batteries only measuring error owing to transfer resistance	
Rectified sine wave	inexpensive	
Pulsating current	obviates measuring errors	
Discharge pulses	obviate production of gas improves retention capacity	
Pulsating peak current	improves retention capacity reduces crystallization	

lene and lithium carbonate.

CHARGING

Secondary batteries that are discharged, or nearly so, must be recharged. A number of charging methods have been developed in the past few decades. Many types of integrated circuit for charging applications are available from a number of manufacturers.

There appears to be a particular charging method for each type of secondary battery. NiCd batteries are known for the large peak currents they can provide, so that, conversely, large charging currents may be used as well. If a NiCd battery is charged at 4C it is fully charged in about 15 minutes (this is called ultra-rapid charging; rapid charging, that is with a charging period of about one hour, is far more common nowadays – see earlier comment on mobile telephones).

CHARGERS

The function of a charger is easily described: it must pump current into the battery until this is fully charged. A good-quality charger detects the moment the battery is fully charged. The requisite electronics may do this by monitoring the voltage at the battery terminals, the rising battery temperature, or the production of gas in the battery.

Lead-acid batteries are charged by applying to them a fixed voltage (higher than the battery's e.m.f.). Current limiting ensures that the charging current does not exceed a given value. When the battery is fully charged, the current automatically drops to a lower level.

In many cases, the charging current need not be regulated, nor even smoothed. For instance, the output voltage of a rectifier may be applied via a resistor directly to the terminals of a NiCd battery.

Another method is charging with a pulsed constant current. During the time between two pulses, the voltage across the battery is measured as a check on the state of charge.

In another method, the battery is discharged for a short period after it has been charged. This is done to reduce the production of gas in the battery. An additional benefit is that it improves the charge retention in NiCd batteries.

Batteries may also be charged with very high current pulses. In this method, the average level of the current depends on the pulse-pause ratio. This method also improves the charge retention of NiCd batteries. Moreover, it reduces crystallization, which causes the battery capacity to drop slightly with every charge/discharge cycle. The characteristics in **Figure 4** show the amount of crystallization as a function of the number of charge/discharge cycles. They also show that small charging currents (below 0.1C) damage the battery. It is far better to use a high charging current with a small pulse-pause ration.

[960018]

3

Figure 3. Batteries are produced in a large variety of shapes and sizes. Shown are two units in modern versions of which NiMH batteries are used: a notebook computer and a portable radio telephone.

References:

Battery Reference Book, 2nd Edition, by T.R. Crompton (Butterworth-Heinemann 1995)

'Batteries', Elektor Electronics, December 1994.

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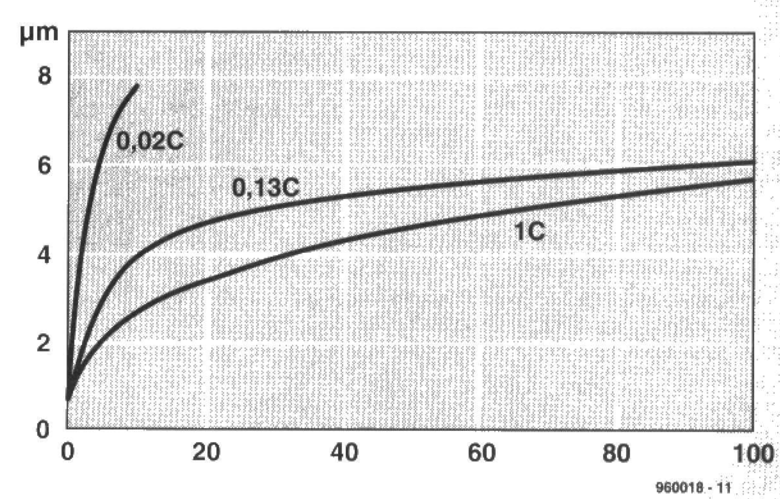


Figure 4. These characteristics show that crystallization is increased by small charging currents. The larger that current, the smaller the degree of crystallization. The degree of crystallization is given on the y-axis and the number of charge/discharge cycles on the x-axis.

Will Emil Jauhari, who recently wrote to us, but who forgot to give his address, send us the address so that we can answer his letter.

[Editor]

FRUSTRATED WITH BLACK BOXES

Dear Editor—I have been purchasing *Elektor Electronics* for many years but I have become more and more frustrated by the increasing number of projects which are incomplete. A primary reason for reading the magazine is to learn about electronics and design. Enjoyment and learning come from building and modifying circuit from scratch with my own PCB and devices purchased at my local store.

More and more circuits use programmable parts: FPGAs, (E)PROMs, PALs, GALS or microprocessors. *Elektor Electronics* has published a number of programmers over the years to enable the leisure user to program these devices. This leaves me baffled as to why you are publishing articles detailing a single microprocessor solution (a PIC in April and a 51 in May, to name but two) with little external circuitry of note (as expected) and no software. Why not let us learn from these prime examples for ourselves? Instead, you offer the (pre)programmed devices at inflated prices, presumably to cover costs and programming. I do not understand why when you publish articles detailing programmable devices and, in the case of processors instruction sets, you do not offer source code. I cannot modify any programmed device to my own liking and might as well purchase a ready-built unit.

I appreciate that some listings may be too lengthy, but no external offer is made either. Can I download it from a BBS or Internet? Can I acquire the source from your Readers Services page? In a word, no. I always enjoyed *Elektor Electronics*, but the shine has gone. The level of projects in the magazine appeared to me to be just a bit better than other magazines' efforts and definitely better presented. Shame it's just about how to assemble the kit of parts now ...

Alex de Vries
Norwich

Your comments are much appreciated. We do publish our various magazines in order to give readers the opportunity of learning about electronics theory and design. Unfortunately, we live in an age of 'black boxes', such as EPROMs, GALs and so on. In some case, we might be able to publish the programs contained in such devices, but mostly the copyright does not allow us to do so. Moreover, often the copyright does not allow the program to be modified. This is frustrating, both to our readers and to our designers. Regrettably, we all have to learn to live with this, admittedly unsatisfactory, state of affairs. We will do our best to avoid projects that use such devices, but this may not always be possible in the interest of a number of readers who do not mind preprogrammed devices they cannot analyse.

[Editor]

COPYING AUDIO ON A VCR
(Letters May 1996)

Dear Editor—It is possible to record audio only on a non-hi-fi VCR, since audio and video are recorded on different parts of the tape. In case of a VCR equipped with a SCART input (or, for that matter, any form of line input), the reason behind a failure to record audio only signals may lie with the input-muting circuit that controls both video and audio muting by detecting a signal on the video input. It can work by comparing the AGC voltage with a reference voltage corresponding to video strip gain at which the input signal is considered too small for satisfactory recording, or detecting the locked condition of the sync separator. It is, therefore, possible to 'unmute' the inputs by feeding a 15625 Hz pulse train (or even sine wave) into the video input. Care should be taken not to overload the circuitry as the standard input sensitivity is 1 V_{pp}, so the sync pulse level will be around240 mV_{pp}.

Another good source of video signal is a TV games console with AV input (connect video only!). If the games console has got only RF output, the CVBS signal can be taken from the RF modulator's input (there are usually only 3 connections: supply, CVBS and audio). Such audio recording will not even remotely approach hi-fi standard, as the best one can achieve is a bandwidth of 70 Hz to 8 kHz. The way to improve it is to design an ADC and DAC with sufficient error-correcting capability to cater for drop-outs and other imperfections of the tape, and record it as a video signal.

It would require a certain amount of lateral thinking and knowledge of VCRs to make the signal acceptable for VCR recording (for instance, it must incorporate a 50 Hz sync signal that is used not only as vertical sync, but also for tracking and change-over of the helical video tracks). A video bandwidth of 3 MHz should be sufficient to record digital audio.

I hope your correspondent J. van Oyen will find the above remarks helpful; I wish him success in recording sound on VCR.

Marcin Frankowski
Warsaw & New Zealand

Dear Editor—Following the letter from J. v. Oyen (Letters 5/96), a suggested approach would be to pick up the 'TEST' signal from the VCR and use this to give the necessary sync signal. This could also be done successfully with a short link lead from the RF output to RF input socket on the back of the VCR, but then tuning the VCR to its own test signal complicates the process. A third way would be that used by a friend of mine, who uses an Amiga to generate a 'Test Card' signal.

Mark Sinden
Portsmouth

Thank you both for this information which will, no doubt, be of great interest to not only Mr van Oyen, but also a number of other readers.

[Editor]

HARMONIC DISTORTION METER
(July/August 1996)

Dear Editor—Having just read the article on the Harmonic Distortion Meter, I find that there is something of a conceptual problem in the design. There have been, in the past, many attempts to try the same idea in other publications, all of which have fallen into the same traps. This is not to belittle the idea, but merely to give an alternative perspective into discovering distortion on an audio signal.

The most effective method of removing an original signal to leave only the unwanted product is to use a mixer. To match the 'test circuit' parameters requires a phase and amplitude matching circuit prior to the mixer master input. However, the complexity of this part of the circuit is less than the twin T filter and has the advantage that it can operate over a very wide range of frequencies. There is in effect no calibration of the circuit with the exception of adjustment of level and phase.

Since most constructors will have the minimum of equipment to test the device and that this equipment will be of dubious 'quality and calibration', it is unlikely that distortion measured in this manner would be less than 0.5% but 1% would be more likely.

With the mixer technique, the oscillator distortion is nulled in the mixer, thus improving on the products resulting from the test.

Of course, the mixer approach allows considerable development into a true instrument rather than the somewhat primitive device you have shown. Component count is not greatly higher for a much more accurate and more professional device. It is possible to design a distortion meter and simple spectrum analyser into one box by providing ramped control voltages to the oscillator and oscilloscope.

Your picture at the bottom of p. 27 shows an engineer in a clean workshop environment with in excess of £5000 of equipment. It is quite another matter for the average home budding boffin in his/her bedroom or garden shed to achieve similar results.

I feel your magazine is the best 'constructor' magazine of its type and will continue my subscription as there seem to be no others offering a similar standard. I am an engineer currently working for the Sema Group, a large multi-national computer software company as a network, hardware and software technician. I also have a home electronics repair business and design and develop electronic hardware for other companies on an ad hoc basis. Thanks again for a great read.

D. Tutt
Chatham, Kent

Your letter has been forwarded to the relevant designer for comment. In the mean time, we welcome reactions from other readers on this topic.

[Editor]

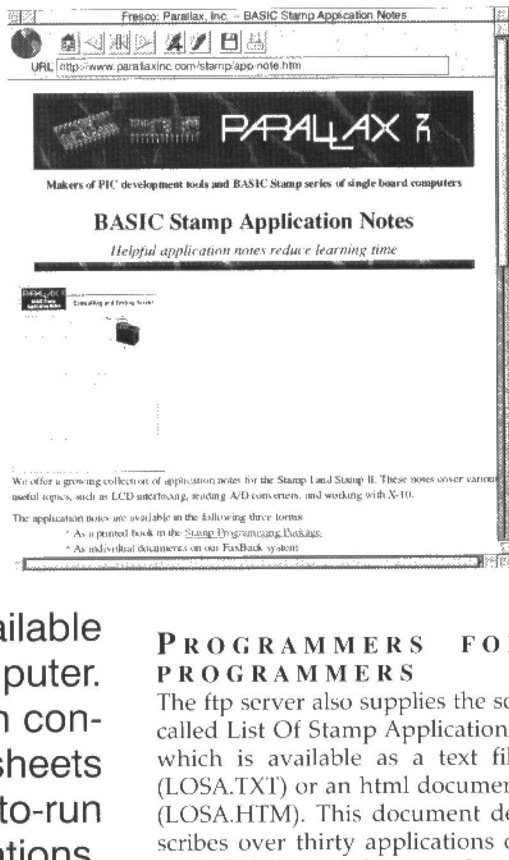
electronics on-line

Webbed, too: the Parallax BASIC Stamp

When it comes to developing practical applications, many electronics designers go for a computer. Because a computer often gives access to the Internet, a lot of relevant information is collected via the Net. For users of the BASIC Stamp from Parallax (series I or II) the Internet has a solid amount of information available on this tiny computer. This information consists of datasheets and ready-to-run applications.

By our Editorial Staff

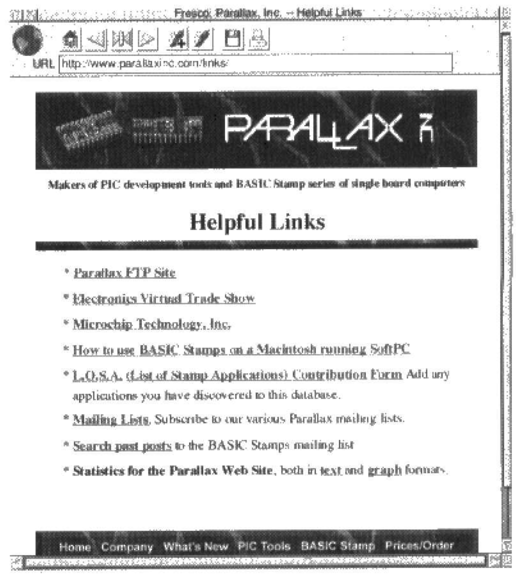
Although the many powerful search engines available on the Net will ultimately enable you to the find the desired information, the exercise may be tedious and time consuming. The good news is that it has been done for you, and we are pleased to present the most interesting addresses we came across during our search for anything related to the Parallax BASIC Stamp computer. Type the Internet URL **http://www.parallaxinc.com** to surf to the home base of the Stamp computer, hosted by Parallax Inc. The makers of the BASIC stamp have used a PIC controller from Microchip Inc., and loaded it with a BASIC interpreter. Apart from the BASIC Stamp, Parallax Inc. also supply a range of development tools (both hardware and software) for its RISC processors. The www (world wide web) site gives easy access to information about these products. Much more interesting, however, is the direct link to the ftp server, **ftp://ftp.parallaxinc.com**. The directory 'pub' (for public domain) contains files which are available for general use.



PROGRAMMERS FOR PROGRAMMERS

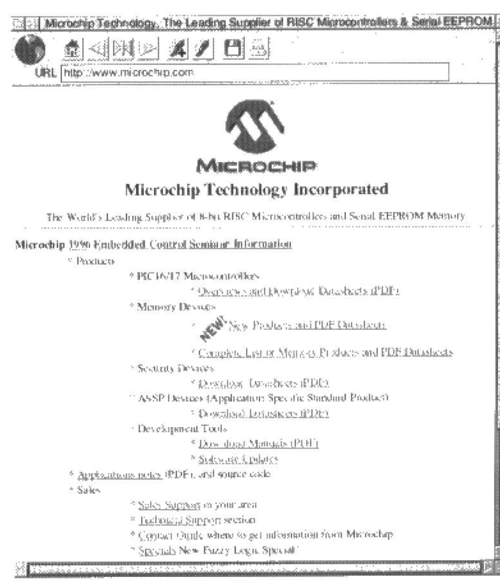
The ftp server also supplies the so-called List Of Stamp Applications, which is available as a text file (LOSA.TXT) or an html document (LOSA.HTM). This document describes over thirty applications of the BASIC Stamp, a large number of which may be used straight away. In some cases, even the complete software is available from an Internet address. The aim of LOSA is to encourage users of the BASIC Stamp to exchange their knowledge and experience with others who have access to the Net. In many cases, the applications indicate the original designer's e-mail address, too.

Parallax themselves also chip in on their ftp site with two Adobe Acrobat documents, called bs1apps.pdf and bs2apps.pdf. These documents contain twenty applications for the BASIC Stamp I, and two for the BASIC Stamp II, respectively. The articles presented in these documents form excellent starting points for any programmer, because they show how the BASIC Stamp is interfaced with external hardware. The articles also provide highly



useful programming examples. Applications that may be found in these documents include a model train controller, the use of X-10, and the use of PWM (pulse width modulation) to generate an analogue output voltage.

The Parallax site has a very useful link to a Swedish site, **http://www.hth.com** run by High Tech



Horizon, the driving force behind LOSA. The main disadvantage of this site is that the information is available in Swedish only. Hopefully, this will be changed to English in the near future.

The Parallax ftp site also contains datasheets of a number of PIC families (-5x, -64, -71 and -84). These documents are again available for both the BASIC Stamp I and II, and may be downloaded as pdf files (Adobe Acrobat).

(965064)

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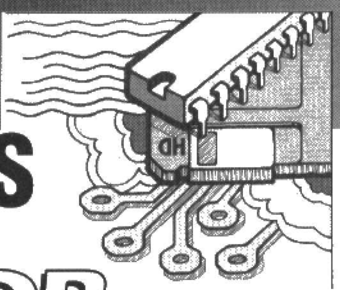

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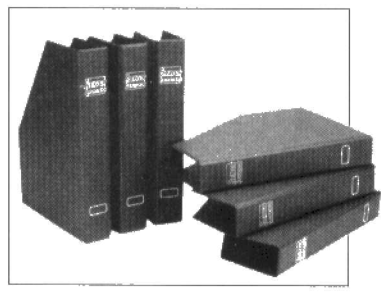
Mini Audio DAC	940099-1	14.75	29.50
1-to-3-phase converter:			
- PCB + GAL + EPROM	940077-C	52.75	105.50
- GAL	946640-1	12.25	24.40
- EPROM	946640-2	15.75	31.50
P.O.S.T. diagnostic card:			
- PCB + GALs (946639-1/2)	950008-C	29.25	58.50
- GAL-1	946639-1	11.00	22.00
- GAL-2	946639-2	13.00	26.00
Self-loading EEPROM type X88C64 SLIC	940116-1	8.25	16.50
Debugging 8031/8051 microcontroller systems:			
- PCB + disk (946203-1)	940117-C	15.00	30.00
- software on IBM PC disk	946203-1	11.50	23.00
DECEMBER 1994			
In-car audio amplifier (3)	940078-2	30.25	60.50
RF immune power supply	940054-1	9.00	18.00
ispStarter kit from Lattice:			
- PCB + disk (946204-1)	940093-C	21.50	43.00
- Examples on PC disk	946204-1	9.75	19.50
NOVEMBER 1994			
Single-wire communication	940055-1	4.00	8.00
In-car audio amplifier (2)	940078-2	30.25	60.50
Solid-state disk:			
- PCB + EPROM (946641-1)	940085-C	47.50	95.00
- EPROM 27256	946641-1	23.50	47.00
Simple capacitance meter	940091-1	10.00	20.00
OCTOBER 1994			
Motive-battery charger	940083-1	7.25	14.50
Integrated AF amplifier:			
- output amplifier board	936062-1	9.50	19.00
- preamplifier PCB	936062-2	28.25	56.50
Tester for IR remote control	940084-1	6.50	13.00
In-car audio amplifier (1)	940078-1	14.00	28.00
TV line monitor:			
- PCB + PIC (946643-1)	940065-C	26.25	52.50
- PIC 16C54	946643-1	20.25	40.50
SEPTEMBER 1994			
Switchable a.c. supply	934004	6.50	13.00
Compact frequency meter	940051-1	9.00	18.00
Revolution counter:			
- sensor board (option)	940045-1	6.00	12.00
- main board	940068-1	5.50	11.00
JULY/AUGUST 1994			
General purpose IR volume control	930099	9.00	18.00
IR controlled switch	936066	9.75	19.50
MIDI swell pedal:			
- PCB + EPROM (946635-1)	940019-C	26.75	53.50
- EPROM 27C64	946635-1	13.75	27.50
Charge meter	940033-1	5.75	11.50
Joystick-to-mouse adaptor	944040-1	7.00	14.00
Centronics I/O interface	944067-1	8.75	17.50
80C451 controller board	944069-1	15.00	30.00
Robust AF power amp	944075-1	9.75	19.50
PC over-temperature alarm	944076-1	4.25	8.50
1-4 MByte SIMM adaptor	944094-1	15.50	31.00
Optical doorbell	944080-1	6.25	12.50
PIC experimenting board	944105-1	17.75	35.50
RC5 transmitter with 80C535:			
- PCB + disk (946199-1)	944106-C	13.00	26.00
- software on IBM PC disk	946199-1	9.75	19.50
Small loop antennas:			
- software on IBM PC disk	1951	10.75	21.50
Software emulation of RC5 infra-red code:			
- software on IBM PC disk	1901	10.75	21.50
PIC programming course:			
- files and misc. utilities on IBM PC disk	946196-1	9.75	19.50
JUNE 1994			
80C535 SBC extension:			
- software on IBM PC disk	1941	9.75	19.50
- I^2C display software on IBM PC disk	946197-1	9.75	19.50
I^2C bus booster	940057-1	7.25	14.50
RS485 interface	940035-1	6.25	12.50
Fuel consumption monitor	940045-1	6.00	12.00
Intelligent EPROM eraser	940058-1	9.00	18.00
MAY 1994			
Mains signalling system - 2:			
- transmitter PCB, disk (1911) and EPROM (6371)	940021-2C	33.25	66.50
- EPROM 27C64	6371	13.25	26.50
- software on IBM PC disk	1911	9,75	19.50
APRIL 1994			
Mains signalling system - 1:			
- receiver board	940021-1	10.25	20.50
68HC11 processor board	930123	7.75	15.50
Headphones amplifier	940016	18.75	37.50
MARCH 1994			
80C535 assembler course:			
- EMON52 ROM + disk (1811)	6221	17.05	34.10
- disk (IBM PC format)	1811	8.80	17.60
100W AF amplifier			
- adaptor board	930039	8.25	16.50
- amplifier board	920135-1	19.40	38.80
- protection board	920135-2	7.95	15.90
FEBRUARY 1994			
80C535 single-board computer	924046	14.10	28.20
Copybit eliminator:			
- PCB + MACH + GAL	930098-C ●	46.25	92.50
- MACH + GAL	6321	42.25	84.50
Mini preamplifier	930106	29.25	58.50
Bidirectional RS232-to-Centronics converter	930134	14.00	28.00
JANUARY 1994			
SIM — an 8051 simulator			
- software on IBM PC disk	1931	34.25	68.50
Digital dial	920161	12.75	25.50
RDS decoder:			
- PCB + EPROM (6331)	930121-C	23.75	51.50
- EPROM 27C64	6331	14.50	29.00
I^2C tester:			
- PCB + GAL (6341)	930128-C	36.25	72.50
- GAL type 6001	6341	30.75	61.50
Telephone-controlled switch			
- EPROM 2764	6271	14.50	29.00
DECEMBER 1993			
535 card with EPROM emulator:			
- GAL and PAL	6311	26.00	52.00
RMS AF voltmeter:			
- PCB	930108	12.25	24.50
- front panel foil	930108-F	17.25	34.50
I^2C power switch	930091	6.25	12.50
Medium power HEXFET amplifier	930102	12.75	25.50
Microcontroller-driven UART:			
- PCB	930073	4.75	9.50
- ST62T10	7151	17.25	34.50
SCART switching box	930122	14.25	28.50

***Elektor Electronics* slipcase**



Price: £2.95 + P&P (£1.50 UK; £2.00 outside UK)

Article title	Order no.	Price (£)	(US$)
NOVEMBER 1993			
Precision clock for PCs:			
- PCB + disk (1871)	930058-C	12.25	24.50
- software on IBM Pc disk	1871	8.50	17.00
VHF/UHF TV tuner			
- PCBs -1 and -2, and µC 87C51 (7141)	930064-C	57.25	114.50
- µC 87C51	7141	25.75	51.50
Output amplifier with AF bandpass filter	930071	6.75	13.50
Digital hygrometer:			
- PCB + EPROM (6301)	930104-C	28.00	56.00
- EPROM 2764	6301	14.50	29.00
Power MOSFET tester	930107	32.50	65.00
OCTOBER 1993			
Stereo mixer	UPBS-1	1.95	3.90
MIDI channel monitor	930059	14.00	28.00
Ah meter with digital display	930068	14.00	28.00
Autoranging frequency readout	930034	12.50	25.00
ROM-gate switchover for Atari ST	930005	30.25	60.50
Microntroller-driven NiCd battery charger			
- board and ST62E15	920162-C	25.50	51.00
- ST62E15	7071	10.00	20.00
Fuzzy logic multimeter - 2:			
- PCB + Fuzzy Control One	920049-C	23.75	47.50
- Fuzzy Control One disk	1721	7.75	15.50
SEPTEMBER 1993			
Fuzzy logic multimeter -1	920049-2	20.00	40.00

Article title	Order no.	Price (£)	(US$)
Linear temperature gauge	920150	7.05	14.10
PC-aided transistor tester:			
- PCB	920144	9.75	19.50
- software on IBM PC disk	1781	7.50	15.00
Harmonic enhancer	930025	13.50	27.00
I²C alphanumerical display:			
- PCB + disk (1851)	930044-C	14.25	28.50
- Software on IBM PC disk	1851	8.50	17.00
Mini micro clock			
- PCB	930055	7.50	15.00
- clock: ST62T15	7111	11.50	23.00
- darkroom timer: ST62T15	7121	11.50	23.00
- cooking timer: ST62T15	7131	11.50	23.00
950-1750 MHz converter	UPBS-1	1.95	3.90
JULY/AUGUST 1993			
Active 3-way loudspeaker system	930016	21.50	43.00
Maxi micro clock			
- PCB	930020	15.50	31.00
- clock: ST62T10	7081	11.50	23.00
- darkroom timer: ST62T10	7091	11.50	23.00
- cooking timer: ST62T10	7101	11.50	23.00
SMD soldering station	930065	9.50	19.00
VHF-low converter	926087	15.50	31.00
I²C bus fuse (5 on 1 PCB)	934016	8.00	16.00
Voice operated recording	934039	6.00	12.00
General transformer PCB	934004	6.50	13.00
Plant humidity monitor	934031	4.50	9.00
Plant humidity monitor (supply)	934032	4.00	8.00
Four-fold DAC card for PCs:			
- GAL	6251	10.75	21.50
Multi-purpose display decoder:			
- EPROM 27128	6261	11.50	23.00
JUNE 1993			
Spectrum VU meter	920151	13.00	26.00
GAL programmer upgrade:			
- PCB	930060	4.50	9.00
- software on IBM PC disks	1701	11.15	22.30
- idem. w/o Opal Jr. disks	1881	10.75	21.50
- software on Amiga disk	1841	11.00	22.00
Digital frequency readout for VHF/UHF receiver	926001-2	11.50	23.00
Inexpensive phase meter:			
- main board	930046	9.00	18.00
- meter board	920018	4.70	9.40
- front panel foil	930046-F	17.25	34.50
X2404-to-8751 interfacing:			
- software on IBM PC disk	1891	8.50	17.00

Article title	Order no.	Price (£)	(US$)
MAY 1993			
FM stereo signal generator	920155	23.00	46.00
Philips preamplifier:			
- PCB	930003	7.50	15.00
- software on IBM PC disk	1861	8.50	17.00
APRIL 1993			
Audio power meter	930018 ●	10.25	20.50
Video digitizer for PCs			
- PCB + disk (1831)	930007-C ●	37.00	74.00
- Software on IBM PC disk	1831	14.50	29.00
Infrared receiver for 80C32 single-board computer:			
- PCB and disk (1791)	920149-C ●	14.50	29.00
- software on IBM PC disk, also for DTMF decoder	1791	7.50	15.00
4MB printer buffer card:			
- PCB	920009 ●	27.50	55.00
- EPROM 27C64	6041	15.30	30.60
- front panel foil	920009-F ●	8.25	16.50
MARCH 1993			
Linear sound pressure meter	930006 ●	7.00	14.00
Electrically isolated RS232 interface	920138 ●	10.25	20.50
TV test pattern generator for 8032 SBC:			
- EPROM 27256	6151	15.30	30.60
FEBRUARY 1993			
Digital audio/visual system (4):			
- software package, EPROM, GALs and IBM PC disk	6181	30.50	61.00
U2400B NiCd battery charger:			
- PCB	920098 ●	8.75	17.50
- front panel foil	920098-F ●	8.75	17.50
Digital-audio enhancer	920169 ●	14.25	28.50
I²C opto/relay card:			
- PCB	930004 ●	11.00	22.00
- software on IBM PC disk	1821	7.65	15.30
Watt-hour meter:			
- PCBs -1 and -2, and EPROM (6241)	920148-C ●	37.25	74.50
- EPROM 27256	6241	10.00	20.00
DECEMBER 1992			
1.2 GHz multifunction frequency meter:			
- PCB + EPROM (6141)	920095-C ●	29.40	58.80
- EPROM 27C256	6141	11.45	22.90

Article title	Order no.	Price (£)	(US$)
- front panel foil	920095-F ●	13.80	27.60
Output amplifier for ribbon loudspeakers	920135-1 ●	19.40	38.80
	920135-2 ●	7.95	15.90
Peak-delta NiCd charger	920147 ●	4.10	8.20
Mains power-on delay	924055 ●	6.45	12.90
NOVEMBER 1992			
Difference thermometer	920078 ●	5.30	10.60
Low-power TTL-to-RS232 interface	920127 ●	3.55	7.10
OCTOBER 1992			
Wideband active antenna	924101 ●	3.25	6.50
RDS demodulator	880209 ●	5.30	10.60
Pascal routines for Multi-function Measurement Card for PCs: software on disk	1751	9.70	19.40
SEPTEMBER 1992			
EPROM emulator - II:			
- PCB	910082 ●	10.00	20.00
- Software on IBM PC disk	129	6.75	13.50
JULY 1992			
12VDC to 240VAC inverter			
- main board	920039-1 ●	11.15	22.30
- power board	920039-2 ●	6.45	12.90
- front panel foil	920038-F ●	16.15	32.30
JUNE 1992			
I²C display	920004 ●	4.70	9.40
Guitar tuner:			
- PCB	920033 ●	10.00	20.00
- front panel foil	920033-F ●	8.80	17.60
Multi-purpose Z80 card	920002 ●	20.25	40.50
- GAL set (2x16V8)	6111	11.15	22.30
- BIOS EPROM 27128	6121	15.30	30.60
- software on IBM PC disk	1711	7.65	15.30
May 1992			
GAL programmer:			
- PCB	920030 ●	11.15	22.30
- software: see June 1993			
APRIL 1992			
80C32 SBC extension	910109 ●	13.50	27.00
2-metre FM receiver	910134 ●	10.30	20.60
Automatic NiCd charger	UPBS-1	1.95	3.90
LCD for L-C meter	920018 ●	4.70	9.40

Article title	Order no.	Price (£)	(US$)
MARCH 1992			
8751 emulator	920019 ●	12.05	24.10
- EPROM 27C64 + IBM disk	6051	29.40	58.80
A-D/D-A and I/O for I²C bus:			
- PCB	910131-2 ●	6.15	12.30
- software on IBM PC disk	1821	7.65	15.30
FEBRUARY 1992			
I²C interface for PCs	910131-1 ●	14.40	28.80
8051/8032 assembler course:			
- EMON51 EPROM + course disk for IBM PCs (1661)	6061	20.00	40.00
- EMON51 EPROM + course disk for Atari (1681)	6091	20.00	40.00
- course disk for IBM PCs	1661	7.65	15.30
- course disk for Atari	1681	7.65	15.30
JANUARY 1992			
Mini Z80 system	910060 ●	10.60	21.20
Prototyping board for IBM PCs	910049 ●	21.15	42.30
PC-controlled weather station (3):			
- software on IBM PC disk (supersedes 1551 and 1561)	1641	7.65	15.30
DECEMBER 1991			
Class-A power amplifier (2):			
- protection PCB	880092-3 ●	7.50	15.00
- power supply PCB	880092-4 ●	7.60	15.20
Connect-4 software in 2764 EPROM	6081	15.30	30.60
NOVEMBER 1991			
Relay card for universal I/O interface	910038 ●	12.95	25.90
Class-A power amplifier (1):			
- voltage amp. PCB	880092-1 ●	9.95	19.90
- current amp. PCB	880092-2 ●	9.05	18.10
Timer for CH systems	UPBS-2	3.80	7.60
24-bit full-colour video digitizer (extension for Archimedes project):			
- software on Arch. disk	1631	11.15	22.30

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